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PATHFINDING FOR CANADA'S NEW TRANSCONTINENTAL RAILWAY.

By H. V. Ross,* Ph. D.

The great exploratory survey that is being made in Canada preliminary to the building of the new Transcontinental Railway is rapidly nearing completion. Seldom in the history of railroad construction has a survey been made which combined such colossal proportions with difficulties so many and so great; for much of this work has been carried on in regions that lie beyond the pale of civilization, and during a bitter northern winter that came nigh to beating all records for its severity and snowfall. Yet, in spite of the wildness and inhospitality of the country traversed, in spite of the difficulty of transporting men and supplies to points far within the backwoods, and of climatic rigors the very thought of which chills the marrow, this great work has been conducted most successfully, and in less than a year's time from now actual construction will be going on along the whole line, and parts of it probably completed. It is already predicted that the new railway will be ready to haul away the northwest harvest of 1907.

When the people of Canada decided, a couple of years ago, to build another line of railway clear across the northern part of their domain, a bargain was struck with the Grand Trunk Pacific Railway Co., under the terms of which this company is to build the westernmost portion of the Transcontinental, from Winnipeg to Port Simpson, or whatever point is finally chosen as its terminus on the Pacific. The eastern part, lying between Winnipeg and Moncton, is to be built by the Dominion Government itself, at an estimated cost of $100,000,000. This portion of the line is 1,890 miles long, and will be known as the National Transcontinental Railway. The present article deals with the work of survey on this eastern division, which has proceeded continuously since September, 1904. Parts of the country through which it has been carried on have seldom, if ever before, been trod by the feet of white men. The preliminary survey is of peculiar interest in itself, both because it consists largely of the nature of an exploration and because of the unusual conditions under which much of it has been accomplished.

The Commissioners and Chief Engineer of the National Transcontinental were appointed on August 20, 1904, and nine days later held their first meeting at Ottawa to consider the matter of organization and plans of action. The first matter discussed was the question of what work should be undertaken for the autumn and winter rapidly approaching. The Grand Trunk Pacific Railway Co. had already made extensive surveys along part of the proposed route—that is, from Winnipeg easterly to a point in the vicinity of North Bay—which surveys the Government contemplated purchasing. Accordingly, it was resolved to begin work at the extreme eastern end of the route, and plans were evolved for the placing of field parties along the line from Moncton to Lake Abbitibi.

One great problem of the many that had to be considered was that of the best route. For instance, much difference of opinion existed among engineers as to whether a line could be run directly across the Province of New Brunswick. To settle this question it was decided to make two preliminary surveys from Moncton to Grand Falls—one by way of the St. John River valley, the other directly across the country by way of Chipman. A similar difference of opinion existing as to what course the line farther to the west should take, it was decided to explore two routes—one by way of the St. Maurice River, north of Lake Abbitibi; the other by way of the Mattawin River, south of Lake Abbitibi. With these plans in view, the portion of the Eastern Division of the Transcontinental Railway from Moncton to a point west of Lake Abbitibi was divided up into four districts, and arrangements were made to carry on the preliminary surveys rapidly during the winter months.

The Transitman in Winter; Canadian Transcontinental Railway Survey.

From the outset the Commissioners found many difficulties confronting them. First and foremost, they had to assemble engineering staffs and men to make up 34 parties; these had then to be equipped with instruments, tents, provisions, cooking outfits, blankets and other necessaries; transportation facilities had to be provided through large sections of almost unknown country, remote from the bases of supply; and, finally, an office staff had to be organized and a system arranged for the proper carrying on of the enormous business involved in such an undertaking.

Without delay, several departments were organized—an accounting department to look after expenditures and finances generally; a purchasing department to take charge of the buying of all supplies; and a transport department to manage the conveyance of men, supplies and mail to all points along the line of survey.

The organization of the transport service called for the most careful planning and foresight. New routes had to be opened up into the back country, many of them in part with the woodsman's axe; main depots for the storage and distribution of supplies had to be strategically placed at the most advantageous points; and a large number of cachés, or store shacks, established at not distant intervals along the proposed line, from which the working parties could be regularly supplied.

In addition to all this, an elaborate system was devised for the careful handling of supplies, so that from the reports of transport men and store men in the field the officials in Ottawa could tell at a moment's notice the exact quantity of supplies and equipment on hand at any point. Seven transport officers, under a chief, were appointed at various posts convenient to the line, instructed to keep in close touch with the storekeepers in their respective districts, and to make full reports of the commisariat to the Secretary of the Commission. Eleven storekeepers were appointed, instructed to keep minute accounts of all supplies received and distributed, and to render a monthly statement of the same to the transport officers in charge of their respective districts.

On the Maniwaki route, which follows up the headwaters of the Gatineau River, nine dog-drivers and nine axe-men were employed, besides two foremen and two cooks, and by this route 93 tons of supplies were transported into the interior. On the Kippawa route, which runs northwesterly from the Canadian Pacific Railroad station of that name, 18 packers and boatmen and two cooks were set to work, and about 65 tons of supplies forwarded up to Grand Lake Victoria. One hundred and nine tons were transported and cached in the Lake Abbitibi region by a private contractor; about 30 tons more to a point further west and immediately north of Lake Kabinakagami; and more than 30 tons were transported by the Hudson's Bay Company from Nipigon to South Bay, on Lake Nipigon, from which point, with the opening of navigation, they were distributed to several points around this lake.

By the end of March, 1905, the transporting of supplies was well advanced, enough being then stored in places along the line to last the engineering parties during the summer. On the opening of navigation, additional supplies were sent in by all the available canoe and water routes, and stored up in depots and cachés against the coming winter. This work was carried on all last summer.

There are practically 40 cachés distributed along the route. Each caché is in charge of two men, who keep a complete account of all goods

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Fig. 1. The Wilderness.

received and distributed to each party. Included among the cachés are seven larger depots, which are used as distributing centers for supplying the lesser posts. One is at the forks of the Gatineau, one at Grand Lake Victoria, one at McDougall's Rapids, and the others at convenient points on the line. The cachés are rough log buildings, measuring 25 × 30 ft., roofed with logs and tar-paper, and having the chinks between the logs stopped up with moss and clay. Near to each are erected two similarly constructed huts, one in which the storekeeper and his assistants have their living quarters and office, the other a cook-house. In each caché, at any one time, are stored about 20 tons of supplies. It is the storekeeper's duty to see that the quantity does not run out and to forward supplies to working parties along the line whenever requisitioned by the engineers in charge of them.

After provisions are taken by the transport department to the main cachés, which are situated at advantageous points on the larger rivers that cross the line, they are distributed in summer by canoe to the different parties. Each main caché is intended to provision about four parties, and as these parties gradually get farther away from headquarters it is very hard work to keep them properly supplied. Sometimes the transport men have to take these supplies hundreds of miles in canoes, crossing from one lake to another over portages two to four miles long, wading through muskegs, and sometimes navigating the head-waters of rivers which for 10 or 12 miles are not much more than wide enough to allow a canoe to pass through, are extremely crooked and so overhung with branches and brush that the men can only push through with ducked heads at the rate of a mile an hour. The work of portaging is very onerous in some sections where unnavigable rapids or falls occur at intervals of only a few miles. Not infrequently a transport crew is windbound at a lake on account of stormy weather, for the canoes are heavily loaded and easily swamped.

A trip like this takes three or four weeks through the more remote districts. During most of the time the men are constantly soaking wet and find little opportunity of drying their clothes. A frying-pan and a few dishes constitute their kitchen equipment, and they live principally on bacon and bread obtained from the main caché before starting out. Sometimes in summer the men do not take tents, aiming to go as light-handed as possible. With a blanket apiece, they lie out under the trees at night on fragrant bough-beds, and commonly, in summer time, the night air in this latitude is too cold for comfort. When the weather is wet they put up a rough night shelter of boughs and birch bark. In winter the white men in these transportation parties take with them small tents, in front of which they build fires when camping; but for winter service many Indians are hired, who draw in supplies at so much a trip. These Indians will haul 200 lbs. apiece on a toboggan and make 20 miles a day without any great fatigue. At night they build a little fire in the woods, cook their supper and sleep out in the open, wrapped up each man in his blanket, when he happens to have one, which is not always. They go all day through blizzards and storms, walking over frozen lakes and rivers on snowshoes and keeping to the trail only by a sense of feeling, the track being all drifted over with snow and quite invisible.

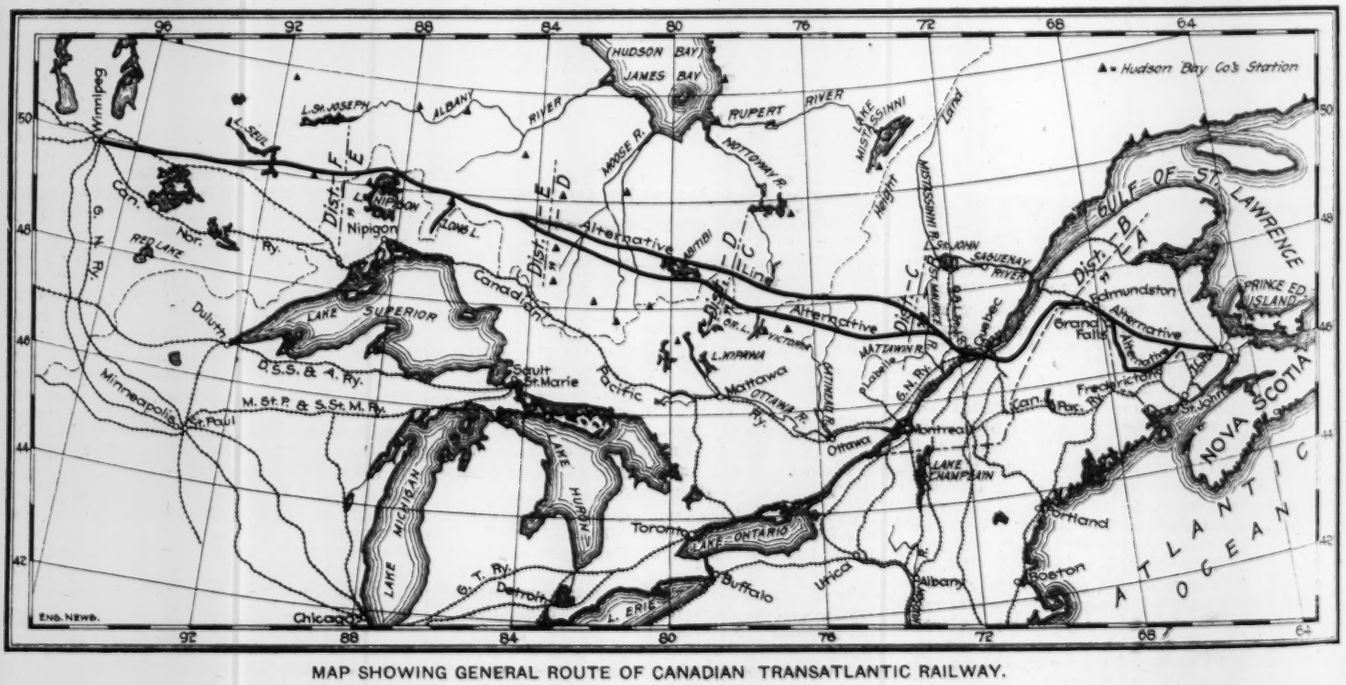
These Indians, and some of the white packers as well, exhibit wonderful powers of endurance. In summer they often carry on their backs loads of 200 and even 300 lbs. over portages from a half a mile to four miles long, suspended on a pack-strap or "tupline" that passes around the forehead, and often go the whole distance without once stopping for a rest. An Indian s... has been observed to stoop frequently ... trudged along and pick berries growing ... the trail, without ever stopping an instant ... stride. One Indian was known to carry as ... as 700 lbs. on his back across a short p... but he was an exception. According to the ... neers, the redmen have lost none of their cu... in woodcraft and still possess the unerri...

Fig. 2. Exploring Party on the Height of Land.

stincts that guide them in long journeys through the frozen and trackless wilds.

The work of transporting is now carried on with comparative ease and certainty, although it continues to be expensive in some sections, the cost of transportation being four or five times the actual value of the supplies. In New Brunswick and the adjacent portion of the Province of Quebec, where the country is more or less settled, teams have been largely used, and the greatest difficulty experienced arose from the unprecedentedly heavy snowfall and the severity of the winter of 1904-5.

Extraordinary difficulty was met with in transporting supplies to the headwaters of the Ottawa and the Gatineau Rivers. The season was well advanced before men, boats and canoes were secured and the supplies started to their northern destinations in the distributing cachés. Before some of these were reached progress was greatly impeded, and rendered dangerous, besides, by the ice that had begun to form on the lakes and the rivers. When winter finally closed in transportation up the Gatineau was carried on by teams from Maniwaki, the terminus of the branch railway, as far as a large caché at the forks of the



MAP SHOWING GENERAL ROUTE OF CANADIAN TRANSATLANTIC RAILWAY.

river, a distance of 115 miles. From this point to the south line of the survey, a distance of 20 miles, and to the north line, a distance of 50 miles, there is neither road nor trail. Through this virgin wilderness the supplies were forwarded by dogteams and packers. The same means were successfully employed through the north Temiscamigue country, to the east of Lake Abbitibi. Greater difficulty was experienced to the north and west of this lake, and in order to reach these points 46 miles of road had to be cut through the bush. The toil and hardship involved in all of this work can hardly be appreciated.

One of the greatest obstacles met with was the slush that forms upon the lakes, making them treacherous and unsafe in the extreme, and in some cases quite impassable. This condition was brought about by the repeated and heavy snowfalls. The superincumbent weight of snow causes the ice to sink and be overflowed with water; subsequent snowfalls accentuate this condition, and finally the whole surface becomes a mass of slush, which never freezes unless broken up. Generally a man will sink through it, and, as the slush is often several feet in depth, the result can be easily imagined. When the lakes are in this condition, long and tedious detours have to be made on snowshoes.

Notwithstanding the dangers of travelling into such a country, no disasters of any consequence occurred in the winter season beyond the loss of one transport officer at Lake Opasatica, on the Temiscamingue route. Going in advance of his party in quest of a convenient course, he was never afterwards seen alive. For several days a diligent search was made for him without result. His tracks on the ice suggested that he had walked out on the lake, broken through and been drowned. His body was subsequently found.

Since the spring of 1905, however, the survey has been claiming its toll in human life, as every great work invariably does. There have been several drownings, due largely to the inexperience of the men in navigating their slight craft on the treacherous lakes and rapids of the north. Early in June an engineer, a transit man and a third man were in a canoe exploring, when they were upset. The engineer and the transit man, who could both swim, struck out for the shore, but before they could reach it sank and were drowned; the third man clung to the canoe and was saved. Sometime later another engineer, in charge of a party near Winnipeg, was traveling in a canoe with three others, when they were overtaken by a storm and the canoe was swamped. The engineer and two packers were drowned, one man only being saved to tell the tale. A few weeks later a man named Desroches fell out of a canoe in the Ottawa River and sank to rise no more, and two men were drowned in Lake Nipigon; and, finally, in October, four of a surveying party were drowned in the Winnipeg River. These cases exemplify the chief danger to the men of the surveying parties. It is, however, an easy matter to get lost in that northern wilderness, as befell a young Englishman in the early summer. While returning from carrying the midday meal to a party of men working on the line at some distance from the camp, he missed the trail, wandered about and got hopelessly lost. He had only three matches with which to make a fire and nothing to eat except three or four small biscuits; yet, somehow, he managed to survive for nine days, until discovered in an utterly exhausted condition by some Indians, who treated him kindly, and finally brought him to a place of safety among white men.

The work of the purchasing department of the survey is not so onerous or exacting as at first glance it might seem. Since the Eastern Division of the Trans-Canada Railway is to be built entirely by contractors, who will furnish their own construction plant and supplies, the purchasing agents of the Commission have to concern themselves only with providing for engineering parties in the field and for the transport service. Up to the end of February, 1905, the purchasing agents had expended nearly $140,000, representing an average outlay of about $23,170 per month. Of the supplies purchased, a very considerable quantity is still stored in cachés for future use. As organized, the purchasing staff consists of eight members, and the accounting department of eight, and both have worked for months with entire smoothness and despatch. It took some time, however, for these departments to get into good running order, for the right men were not always easy to find, and the precise scope of the different departments was not at once clearly defined.

After negotiating for some time with the Grand Trunk Pacific Railway Co., the Commissioners of the Transcontinental purchased for the Dominion Government the surveys made by this company on the main line east of Winnipeg, including their depots, cachés, tents, outfits, provisions, instruments and other equipments, and paid therefor nearly $300,000. The value of the plans and surveys purchased is very great, and will in no small degree expedite the location of the line in the western parts of the Government division. The Commissioners did not, however, accept them as final, and, acting on the advice of Hugh D. Lumsden, their Chief Engineer, concluded to make further explorations. This work has been carried on vigorously in District F, which is the first district east of Winnipeg. Location surveys are pretty well advanced in districts A and B, and it is very probable they will be ready for construction early next year.

All in all, the present survey is considered more difficult than was that of the Canadian Pacific Railway, the chief reason being its greater remoteness from the bases of supply and the difficulties of travel. As a matter of fact, the new line will be considerably shorter and more direct than is its great predecessor, and from a purely engineering point of view it presents fewer problems. But the conditions of labor have somehow changed. Back in 1875, when the first survey of the Canadian Pacific Railway was being made, the workingmen who sought employment appear to have been, on the whole, a much superior class, as regards pluck and stamina, to those who have gone out on the present survey. They received less pay and did satisfactory work, without having the luxuries that are now supplied to engineering parties. For instance, in the old days parties in the field had to get along without butter, condensed milk, ham and fruit, all of which are now part of the field rations; yet in spite of their hard fare, men were then willing to stick to the work. Some of them were known to stay out as long as two years without coming in, whereas now many of the men clamor to return to civilization after a month or two of service.

This is one of the greatest difficulties the officials of the survey have had to contend with. It takes a month or six weeks to replace men at distant points, and in the meantime the parties to which they belong are disorganized. The annoyance and the expense resulting have been very great. Hundreds of men have gone out and have left after working a short time. As a check to this tendency, the Commissioners have drawn up a contract, which every man who is now engaged must sign. It stipulates that he shall give his services to the Commission for nine consecutive months, and should he return prior to the expiration of that period he is to forfeit the sum of $15; that is to say, the cost of getting a man into the backwoods.

A further remedy will be found in the establishment of a proposed telephone line through the back country to some point on the survey line near the sources of the Gatineau River. It cannot fail to be useful in keeping headquarters closely in touch with the state of parties in the field, and will also be of great advantage in other respects; as, for instance, in the matter of ordering provisions and reporting illness or accidents to members of the staff in the field. When construction begins, with 100 men at work on the line where there is now one, contractors will find this telephone line extremely serviceable for ordering men and supplies quickly.

Many of the men who were first hired and went to the interior were found to be physically unfit and either left or were discharged. This experience decided the Commissioners to require all applicants for positions in the field to undergo careful medical examination. As a consequence all the men now employed are physically fit and sound. This is a matter of the highest importance. A young doctor is stationed in the field at Grand Lake Victoria, having the care of four parties of engineers and transporters, 100 men all told. He is always on call, and makes periodical visits to the various camps, where he not only ministers to the sick, but also sees that sanitary conditions are as they should be. His services have proved so valuable that four other doctors are now stationed in the interior—one at the headwaters of the Gatineau; another at McDougall's Rapids, west of Lake Abbitibi; one at North Bay; and one at Nipigon. They are furnished with an ample supply of medicines and all the surgical instruments likely to be needed. Apart from this provision for the health of the men, each crew, when going into the field, takes a well-stocked medicine chest. As soon as construction work begins it is contemplated to provide four or five temporary hospitals in remote sections along the line.

Fig. 3. A Cache, or Supply Depot.

Fig. 4. Packing His Own Kit.

The daily rations of each man in camp is 5.40 lbs. of food, including 1 lb. of bacon and pork and 1 1-5 lbs. of flour. The allowance per month for a party of 18 men is 2,617 lbs., of which the principal items are flour, pork, oatmeal, beans, sugar, molasses, condensed milk, evaporated fruits, butter, salt and pilot biscuits. Only the best of food is furnished.

The work of surveying the 1,890 miles of the Eastern Division is divided into six districts, with an engineer in charge of each, all under the direction of the Chief Engineer, with headquarters at Ottawa. A complete engineering party consists of 18 to 20 men, including the engineer-in-charge, transitmen, levellers, rodmen, chainmen, cook, packers and canoe men. As a general rule, there are approximately eight parties operating in each district, and, as there are six districts, the total number of men on the engineering staff alone is practically 1,000. Apart from this is the transport service, which requires all the way from 80 to 100 men in each district, or a force of nearly 600 men in all.

When a party has worked along for a distance of three or four miles from camp, the camp is then moved to a spot three or four miles in advance of the last point surveyed, and when this is passed again for a like distance it is again removed. The camp is accordingly moved every two or three weeks. With reference to each other, every two parties work east and west from each caché, by which arrangement both are conveniently supplied from it.

The line of survey now mapped down crosses New Brunswick from Moncton by way of Grand Falls and Edmunston, into Quebec, where it sweeps sharply to the southwest near Lake Pohengamook, parallels the St. Lawrence for about 100 miles, then swings northwest and crosses the St. Lawrence near Quebec City; thence it runs directly west for about 60 miles to a point from which two trial surveys branch off: the upper one turns sharply to the north for about 60 miles, passing La Tuque Falls; thence in a northwesterly direction, paralleling a portion of the St. Maurice River, crossing the sources of the Gatineau and traversing the Height of Land a little north of Lake Kapitachuan, after which it takes its way to the north of Lake Abbitibi, passing through much unexplored country to the south and east of James Bay. The lower, or southern, survey line takes a more direct course across Quebec, and is from 20 to 60 miles south of the north line, and passes south of Lake Abbitibi. Beyond this lake the two lines gradually converge and meet in the vicinity of Longitude 86° W.

On Sept. 27, 1904, the District Engineer appointed for Section A—the Province of New Brunswick—organized and started out six parties, and shortly afterwards six other parties, two of which were soon disbanded. They explored from Moncton to the Quebec boundary, a large area of country, and made two separate surveys—one by the back route, running across the province by way of Chipman, to connect with the survey made in District B; the other by the river route, up the valley of the St. John, and thence to Grand Falls. On both these routes many alternative lines were run or explored. The total mileage of preliminary lines covered in this district was 1,320. Nine of the twelve parties engaged in this part of the survey lived continuously under canvas all through the winter. The work was finished by the opening of last March.

A portion of these surveys was run through a rich and well-settled farming country; but a large part of the back line survey passed through an almost entirely unsettled region, covered with spruce, birch, cedar and hardwood. This part of the country, which the railway will open up, is well watered, and is perhaps unsurpassed as a game district by any in the Dominion. Moose, red deer and caribou abound, especially caribou, of which a herd of 15 is not an uncommon sight. Fishermen will also find here a Waltonese paradise on the Rivers Salmon, Miramichi and Tobique, whose stock of salmon it will take many years of fishing to diminish appreciably.

The engineers surveyed this district under most severe and extraordinary conditions, the winter of 1904-5 being a record-breaker for the Province of New Brunswick. For weeks at a time the thermometer went below the zero mark, and at times fell as low as 55° below the freezing point. The snow, also, in many places, more particularly in the central part of the province, lay over 5 ft. deep. As no crust formed on the surface, over which sleds and toboggans could be easily drawn, the work of exploring and moving camp was exceptionally arduous and severe.

The first of 11 survey parties in District B was sent out before the middle of October, and by March 1 ensuing a large area of country had been explored; some 677 miles of exploratory and 540 miles of preliminary surveys were run. The eastern part of this district was found to be difficult of location, owing to the abrupt fall of the country from the Height of Land to Lake Pohengamook. The country to the right and left of the line was carefully explored. The valleys of the streams and rivers were followed as far as possible to obtain easy grades. The highest point the line will attain is 1,580 ft. above sea level, at a point between Lake Pohengamook and Quebec. Between this lake and the Etchemin River it passes through the Alleghany Mountains, a beautiful range from 10 to 20 miles from the south bank of the St. Lawrence. The country along the proposed line is already sparsely settled.

Westerly from Quebec the line runs through a settled country for some 70 miles, but from Reed's Camp northwesterly stretches a primitive wilderness, with no white men except the lumberman and the trapper. During the winter months an army of 5,000 lumbermen is employed in the vicinity of La Tuque Falls, on the St. Maurice River, getting out logs for the busy mills at Grand Mere, Shawenegan Falls and Three Rivers. The Falls of La Tuque, with a capacity of 90,000 HP., are destined to be the center of great industrial activity in the future. As a result of the Quebec survey, the engineers reported that a first-class line had been discovered from Lake Baker, in the east, to Waymontachene, in the west, a distance of 423 miles.

The engineering parties that went into District C found a country entirely uninhabited, except for a few Indians, traders and men of the Hudson's Bay Co. Some of the principal rivers had been more or less explored; but the country lying between these streams was a *terra incognita*. It was found to be dotted with many small lakes, and well wooded with cyprus, birch, tamarack and cedar. Late in the season eight parties went out into this district. They had much trouble in transporting their supplies and made slow progress in reaching their destination. The work of survey was considerably impeded by the frequent lakes and stretches of impracticable country.

The line through District D will open up an entirely new country. It will run close to Lake Abbitibi, where at present the sole inhabitants are the handful of men connected with the Hudson's Bay Co. and fur trading posts. Most of the surveying in Districts E and F was done by the Grand Trunk Pacific Railway Co. The country is rough and broken in places, but much of it is good farming land. There are no accurate maps of these two districts, which fact has added materially to the other difficulties experienced.

A characteristic feature of the country explored is the muskegs, through which many miles of the line have been run. They are swamps not unlike Irish peatbogs, for the most part shallow and covered with small spruce and tamarack. They begin in the East to the north of Montreal, and are met with as far as Winnipeg in the West. A muskeg may be anywhere from 3 to 30 ft. deep or more, although in this northern country many so-called muskegs consist solely of 3 or 4 ft. of moss, overlying clay subsoil. The top of the real muskeg consists of a crust of moss and roots, and one can walk over it if he treads carefully. The bottom, however, is soft and spongy, and if he goes through the top he is liable to sink down to his ears in the watery mass. A marsh of this kind is known jocularly among engineers as a "Julius" muskeg, so named from a Swede who was employed on the Canadian Pacific Railroad survey some years ago. This man was swallowed up in one of these treacherous swamps until only his head remained in sight, and was rescued with difficulty, leaving his boots behind him. In the eastern part of the country the muskegs, being comparatively shallow and firm, offer no engineering difficulties of moment; but further west they are large and deep and expensive to deal with. In the country which the new railway will traverse there are thousands of acres of them, and possibly here will be found a large supply of fuel in the future. Muskeg peat is known to be a valuable fuel, and already speculative eyes are turned towards these quaking muskegs of the north.

As already suggested, a long stretch of the line passes through the wonderful lake region that begins not far west of Quebec City and extends through to Winnipeg. It is estimated that half of this area consists of lakes, some of them being large bodies of water. For instance, Lake Temiscamingue is 90 miles long, Lake Abbitibi 30, and Grand Lake Victoria upwards of 40 miles long. In reality Temiscamingue and Grand Lake Victoria are great lakelike expansions of the upper Ottawa River.

The recent discovery of silver in the vicinity of the first-named lake has drawn the attention of the world to the mineral wealth of this portion of New Ontario, and may be taken as an earnest of discoveries yet to come. But apart from the mineral wealth of this country, the careful and exhaustive explorations of the engineers have made it plain that the new railway will open up for occupation broad areas of agricultural lands, second only to the best in the Dominion, which is saying a good deal.

Fig. 5. On the Water.

Fig. 6. On the Ice.

Traveling on Ground Hog River.

Fig. 7. On Grand Lake Victoria.

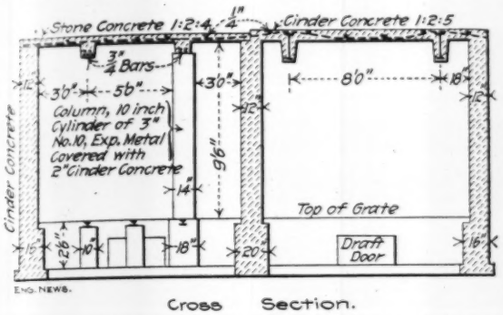
Fig. 8. Unhooking Dogs at Camp.

FIGS. 5 TO 8. TRANSPORTATION BY BOAT, MEN AND DOGS; CANADIAN TRANSCONTINENTAL RAILWAY SURVEY.

A NEW BLOW-PIPE for producing exceedingly high temperatures has recently been introduced in Great Britain. It is a French device and is known as the Fouché Acetylene-Oxygen blow-pipe, using these gases under pressure, in a nozzle similar to that of the oxy-hydrogen blow-pipe. It is claimed that the flame is of extraordinary intensity and calorific power, and will liquefy firebrick and calcium carbide. The temperature reaches 2,300° to 2,400° C. (4,300° F.). At present it is used chiefly in welding processes.

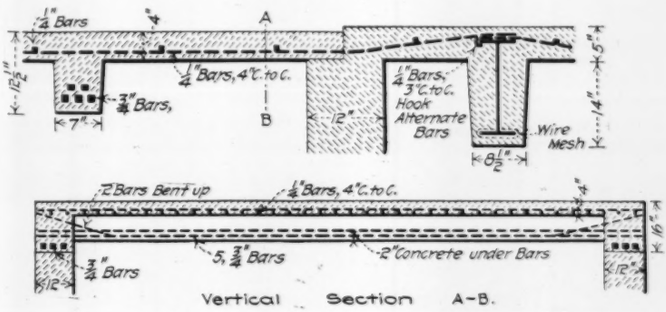
FIRE AND WATER TESTS OF STONE-CONCRETE AND CINDER-CONCRETE FLOORS REINFORCED WITH CORRUGATED BARS.

The accompanying drawings show the construction of two forms of concrete floors reinforced by corrugated bars that were subjected to the standard fire and water test of the New York Building Department on Dec. 26, 1905. Both floors are



Cross Section.

FIG. 1. SECTION OF TEST HOUSE, SHOWING FLOORS IN PLACE.



Vertical Section A-B.

FIG. 2. DETAILS OF FLOORS TESTED.

standard designs of the St. Louis Expanded Metal & Fireproofing Co., as constructed by H. C. Miller & Co., of New York City, at whose expense the tests were made. One floor was a reinforced cinder concrete slab and steel I-beam construction, and the other was a reinforced stone concrete slab and girder construction. The two floors were constructed as roofs to two adjacent compartments of a concrete test house of the form shown by Fig. 1. Fig. 2 shows details of the floor construction. The tests were made at New Brunswick, N. J., under the direction of Prof. Francis C. Van Dyck, of Rutgers College.

OBJECT OF TEST.—The object of the test was to ascertain the result of applying to these floors, first, a temperature of about 1,700° F. during four hours, a load of 150 lbs. per sq. ft. being upon them, and secondly a stream of water forced upon them while still at about the temperature above stated. A column was placed in the chamber roofed by the stone concrete floor, and it was tested the same way.

TEMPERATURES.—The fuel used was seasoned pine wood, and the stoking was looked after by a man experienced in a pottery, hence a very even fire was maintained except at first on the cinder concrete side, where the blaze began in one corner and spread rather slowly for some time.

The junction of an electric pyrometer was suspended 6 or 7 ins. below each floor at its center, and readings of the temperatures were made by Mr. Adolph G. Ahrens, a student in the electrical course, senior year, at Rutgers College. Fig. 3 shows diagrams of the temperature readings. The fires were kept up for ten or twelve minutes after the temperature readings were stopped, hence the averages on both sides were doubtless somewhat higher than those reckoned from the logs. As soon as the pyrometer readings were completed on each side the instruments were removed, and everything made ready for the application of water.

WATER TEST.—The water was supplied from a pump, at which 90 lbs. pressure was maintained, and delivered through 200 ft. of hose and a 1⅛-in. nozzle. Each side was treated while at full temperature, apparently, and the water was thrown as uniformly as possible over the surface to be tested for the required time. The floors were then flooded on top and again treated underneath.

EFFECTS.—The column was practically intact, except that a few small pieces of concrete were washed out where struck by the stream at close range. But the metal remained completely covered. On the rock concrete side the beams showed naked metal up to within about 7 ins. on the ends on one beam, and about 2 ft. from the ends on the other beam. The reinforcing bars were denuded over an area of about 30 sq ft. near the center, but no cracks developed, and the water poured on top seemed to come down only through the pipe set in for the pyrometer. On the cinder concrete side the beams lost only a little of the edges of the covering, not showing the metal at all. There were no cracks on this side, either, and the water came down through the pyrometer tube, as on the other side. The metal was bared over an area of about 24 sq. ft. near the center.

During the firing both chambers were examined occasionally, and no one could see the least cracking or flaking off anywhere of the concrete. The water did all the mechanical damage that was apparent at the end.

DEFLECTIONS.—The deflections were measured by Mr. W. R. Hughes, Jr., a junior in the civil engineering course at Rutgers College. The attached table of deflection readings give full particulars of this feature of the test, including

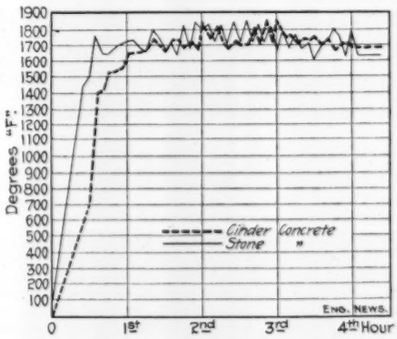


Fig. 3. Diagram of Temperature Readings.

what occurred during the firing under load, and subsequently upon the application of a load of 600 lbs. per sq. ft.

TABLE SHOWING DEFLECTIONS AT CENTERS OF FLOORS AT VARIOUS TIMES DURING TEST.

Time.	Deflection in inches. Stone concrete.	Cinder concrete.
11.30	5/16	1 1/16
12.00	9/16	1 7/16
12.30	1 1/16	2 5/16
1.00	1 13/16	3 1/16
1.30	2 1/16	3 13/16
2.00	2 7/16	4 15/16
2.30	2 15/16	6 1/16
After water	3 5/16	6 1/2
After 600-lb. loading.	3 13/16	6

HEATING AND VENTILATING THE MAIN AUDITORIUM OF THE BROADWAY TABERNACLE, NEW YORK CITY.*

By C. Teran.†

The heating and ventilating of a church auditorium has always been an interesting problem, for there are conditions found, and difficulties to overcome, in an auditorium of this kind that do not occur in the ordinary building, such as large glass surfaces, which are the source of cold drafts, little floor space, for placing radiators, the necessity of placing radiators near seats, making these seats undesirable.

In this case there was one difficulty to contend with, namely, that under the auditorium there is a hall, which had to be left free of pipes and other objectionable features from an esthetic point of view; in other words, there is no cellar in which pipes and ducts could be placed. A space between the auditorium and the ceiling below was provided for this purpose. This space is about 3 ft. deep, but as it is due to the depth of the girders that carry the floor its usefulness for placing pipes and ducts was limited, as can readily be understood.

After carefully considering all these points it was decided to use the blast system of heating, with mechanical exhaust and automatic temperature control for the auditorium, and direct radiators controlled by hand for the vestibules.

The blast system was considered the best in this particular case for the following reasons:

First—Low cost of installation.

Second—The objectionable radiators are done away with.

Third—From a sanitary point of view the fact that the place cannot be heated without at the same time ventilating it.

Fourth—Even distribution of heat.

The seating capacity of this auditorium is 1,500. The apparatus was designed to supply 25 cu. ft. of air a minute per person to 1,600 persons, or a total of 40,000 cu. ft. of air a minute.

It may be mentioned that, in this case, 25 cu. ft. a minute per person was about the maximum amount of air that could be introduced without causing drafts and noise, even by introducing a large proportion of the air through top inlets. The entire use of bottom inlets would have been impossible without causing drafts, or considerably reducing the amount of air supplied.

A three-quarter housed centrifugal fan is used to supply the air. This fan has a blast wheel 9 ft. in diameter by 4½ ft. wide, driven by a direct connected motor, and is designed to deliver 40,000 cu. ft. of air a minute, at 130 R. P. M.

The heat transmitted through walls, windows, etc., was calculated to be 340,000 B. T. U. per hour, with 70° F. difference between the inside and outside temperature. Given these conditions, the incoming air would have to be heated to 78° F. to supply this loss. This is accomplished by drawing the air through a heating stack, consisting of ten two-row sections, or coils of steam piping of the miter type. These coils are built in staggered rows of 1-in. pipe, and the stack contains 7,500 lin. ft. Each section has two steam and one return connection. The air is taken from a court at the ground level, and for this reason the intake was made large, to insure a low velocity of the air in the immediate outside vicinity. This opening is fitted with a wire screen and louver damper, and through it the air is directly admitted to the filter room. The filter is of the "V" type, made of galvanized iron, with removable wooden frames, covered with wire and cheesecloth in the usual manner. The filtering area is proportioned to allow 32 cu. ft. of air a minute to pass through every square foot of filtering material.

From the filter room the air is induced through the heating stack into the fan, then discharged by this into the distributing ducts and flues, leading to the auditorium.

The velocity of the air is reduced in the ducts to 1,900 ft. a minute, and in the flues to 900, and finally discharged at 600 through the top registers and 200 through the floor registers.

Heat registers are placed on the side walls from 8 to 12 ft. above the main auditorium and gallery floors. There are also heat registers in the floor in front of the large windows, and in the step risers of the front gallery. The air discharged by the registers in front of windows, is intended to counteract the cold air drafts produced by these cooling surfaces. A large proportion of the air is introduced on the same side as the pulpit, so that its travel is in the same direction as the voice of the speaker, thus aiding, or at least not interfering with the acoustics of the auditorium.

The equal distribution of the air is obtained to a large extent by the location of the exhaust openings. Each pew end on the main floor has an opening near the floor, forming part of the design of the ends of the pews, and connected with the space underneath the auditorium before referred to, which is also used as an exhaust chamber. The connections between this chamber and the openings in the pew ends are made by cast-iron

*A paper read before the annual meeting of the American Society of Heating and Ventilating Engineers at New York City.

†Heating and Ventilating Engineer for the contracting firm of Walker & Chambers, 50 E. 20th St., New York City.

hoods, placed against the inside of the pew ends, and covering both the opening in the pew end and that in the floor leading to the exhaust chamber. These hoods are provided with controlling dampers, to regulate the flow of air through them.

The exhaust chamber is connected at one end to a Blackman exhaust fan 6 ft. in diameter. This fan is driven by a direct connected motor and discharges into the open air. It is intended that when this fan is revolving at 300 R. P. M. it will exhaust 32,000 cu. ft. of air a minute, or 80% of the amount supplied by the blower.

When the apparatus is started in operation, the air is introduced at as high a temperature as the heater coil will heat it, until the temperature in the auditorium has reached the maximum required, then the air is introduced tempered, only until the temperature in the auditorium falls below the normal, when the air is again heated to a higher temperature to supply the loss.

This is accomplished, automatically, by thermo-pneumatic control, as follows:

Three sections of the heating stack have separate steam connections and are controlled by a thermostat placed in the cold air chamber. This thermostat is set to operate at a temperature a few degrees above freezing, about 40° F.

The rest of the heating stack is controlled by two thermostats, one placed in the auditorium and set to operate at 65° F., and the other in the main warm air duct, also set to operate at 65° F. Both of these thermostats operate the same set of valves, controlling the inner seven sections of the heating stack. The thermostat in the duct, however, is so connected that it can only act when that in the auditorium has operated to shut off heat, during which period of time it will maintain the air at the temperature at which it has been set. By this arrangement the same stack is alternately used as a heating and tempering coil.

In this, as in all other auditoriums, the heating apparatus is shut down until a short time before the audience is admitted. On this account there is a desired advantage in having the tempering and heating coils combined in one, for when heat is turned on the whole stack is active until the required temperature is attained in the auditorium. This makes the period of heating up shorter than it would be if the tempering and heating coils were separate.

The apparatus has been in operation for some months, and although the weather conditions have not been favorable for an exhaustive test, the tests that have been made show that it gives the desired results.

FIRE TEST OF A CONCRETE FLOOR WITH BAYS OF DIFFERENT AGGREGATES.*

The object of this test was to determine the effect of fire on a floor composed of seven equal bays of concrete identical in all respects except in the character of the aggregate and the composition of the concrete mixture. The fire was to last three hours, with a temperature reaching 1,800° F., but not exceeding 2,200° F., and was to be followed by the application of a hose stream under 60 lbs. pressure through a ½-in. nozzle to the underside of the floor for a period of two minutes. Previous to the fire test the top of the floor was to be loaded with a weight of 224 lbs. per sq. ft.

CONSTRUCTION OF FLOOR.

The construction of the floor, illustrated in Fig. 1 was as follows: The floor was divided into seven separate bays, each bay being in the clear 10 ft. 2 ins. long by 2 ft. 7 ins. wide between the concrete casing of the beams. There were six rolled steel joists each 6 ins. by 4½ ins., weighing 20 lbs. per foot lineal, the ends being built into the side walls of the hut, 1 in. clear space being left at the ends of each joist. Each joist was encased with coke breeze concrete 9 ins. wide by 10¾ ins. deep, so as to give a minimum of 2 ins. of concrete all round the joist. The bays or slabs of concrete were 5½ ins. thick and were quite separate, resting on a 4½ ins. set off all round the walls of the hut and on the concrete casing to the girders, but not fixed thereto, a space being left between each slab.

The cement used was Portland, supplied by the Associated Portland Cement Manufacturers (1900), Ltd., London, and described by them as "Ferrocrete," used as a trade name for this particular brand of cement.

The particulars supplied by the makers contain the following statement:

(a) Very fine grinding—residue on sieve with 32,400 meshes per sq. in. not exceeding 14%.
(b) Great and progressive tensile strength averaging on the inch section:

	7 days.	28 days.	7 days.	28 days.
Neat cement test	550 lbs.	750 lbs.	249.476 kilos.	340.194 kilos.
Sand test.. (3 sand to 1 cement.)	200 lbs.	350 lbs.	90.718 kilos.	158.757 kilos.

(c) Maximum of expansion—not exceeding 2 m. m. under the Le Chatelier test.

*Abstract of Report on Experimental Fire Test Made Oct. 24, 1905, by the British Fire Prevention Committee, 1 Waterloo Place, Pall Mall. London, England.

The following is a description of the aggregates, giving the amount of aggregate to one part by volume of cement in each case.

I. Furnace Slag Concrete. Bay No. 1. Blast furnace slag from the Islip Ironworks, Thrapston, Northhampton, broken to pass a 1½-in. ring, three parts. Clean pit sand from Kent, two parts.
II. Broken Brick Concrete. Bay No. 2. Broken brick to pass a 1½-in. ring three parts. Clean pit sand from Kent, two parts.
III. Broken Granite Concrete. Bay No. 3. Broken granite, ¾-in. (Guernsey granite chips), three parts. Clean pit from Kent, two parts.
IV. Burnt Ballast Concrete. Bay No. 4. Burnt ballast, viz., clay from the neighborhood of Child's Hill, burnt with slack coal, broken to pass a 1½-in. ring, five parts.
V. Coke Breeze Concrete. Bay No. 5. Coke breeze broken to pass a 1½-in. ring (free from fine dust), from the retorts of a London gas company, five parts.
VI. Clinker Concrete. Bay No. 6. Furnace clinker, viz., the raking from the furnaces of large boilers, broken as last, three parts. Clean pit sand from Kent, two parts.
VII. Thames Ballast Concrete. Bay No. 7. (South Bay). Thames ballast dredged from the River Thames to pass a 1½-in. ring, three parts. Clean pit sand from Kent, two parts.

The concrete casing to the girders was all similar to that in Bay No. V., but the coke breeze was finer.

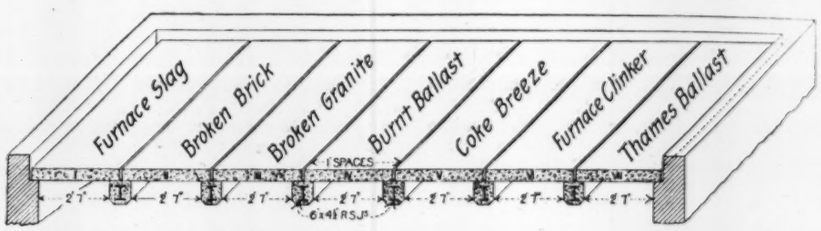


DIAGRAM SHOWING CONCRETE FLOOR COMPOSED OF BAYS OF DIFFERENT COMPOSITIONS AND CHARACTER OF AGGREGATES.

In each case the material was turned both in its dry and wet condition, and the concrete to form each slab laid on the centering in a rather wet state; 1.2 gallons of water were used for each cubic foot of concrete, approximately 20% of water by volume. Slips of wood were fixed at the sides to retain the concrete in its place and form the necessary spaces.

The joists were fixed in position on Sept. 2, 1905. The coke breeze casing was put round the joists forming the beams on Sept. 11. The slabs or bays were commenced on Sept. 12 and finished on Sept. 14. The centering was removed on Sept. 28. The coke breeze casing to the beams was rendered with plaster, ¼-in. thick Oct. 3 to 5.

During the week ending Oct. 7 each separate bay was loaded with bricks equal to a distributed load of 224 lbs. per ft. super. From Oct. 16 to 23 a coke burner ("devil") was kept alight in the testing chamber. The covering was finally removed from the roof on Oct. 24, 1905.

THE TEST.

On Oct. 24, 1905, the test was undertaken. The following is a log of the test. The table shows the temperature taken from the four pyrometer points, Nos. 5, 8, 9 and 10. At 2 p. m. the gas was lighted; from 2-10 p. m. onwards the plastering fell off the beams in patches continuously throughout the test, but nothing occurred to record with regard to the bays; at 5 p. m. the gas was turned off. At 5-3 p. m. water was applied for three minutes at about 65 lbs. pressure through two branches (one through each of the door openings on the east side) each with a ½-in. nozzle. The effect of this was to wash more of the plastering off the beams, but nothing further could be observed. At 5-6 p. m. the water was turned off.

During the test it was observed that the edges of the slabs Nos. I. VI. and VII. were red hot; this was seen from above in the cavity between the edge of the slabs and the wall.

OBSERVATIONS AFTER TEST.

On Oct. 25 the bricks forming the load were partly removed and the whole were removed on Oct. 26. On Oct. 25 observations as to the state of the underside of the beams and slabs were made and on Oct. 27 observations as to the state of top.

Bay No. I. Slag Concrete.—Soffit.—Practically flat on the underside; slight cracks visible corresponding to those on top.

Top.—Slab cracked across in two places into about three equal parts, curved downwards about ¼-in. in the width.

Bay No. II. Broken Brick Concrete.—Soffit.—Curved downwards ¼-in. in the center, in the width; slight cracks visible corresponding with those on top.

Top.—Slab cracked across in three places into four rather unequal parts, the west-end portion of the slab being the largest, very slight curve downwards.

Bay No. III. Granite Concrete.—Soffit.—Curved downwards ½-in. in the center, in the width. About 1 in. washed off the surface in one part and slightly more or less all over the area struck by the water.

Top.—Slab cracked across in three places into four parts, the west-end portion being the largest, curved downwards about ½-in. in the width.

Bay No. IV. Burnt Ballast Concrete.—Soffit.—Slightly curved downwards about ¼-in. in the center in the width. About 3 ins. in depth washed off the surface in one part, along the third beam from the west, the greatest depth being about 3 ft. from the west side of the hut.

Top.—No cracks—not curved.

Bay No. V. Coke Breeze Concrete.—Soffit.—Flat on the underside. About 1 in. washed off the surface all over more or less where struck by the water.

Top.—No cracks—not curved.

Bay No. VI. Clinker Concrete.—Soffit.—Flat on the underside.

Surface pitted in places about 1 in. deep where struck by the water and in one place 2 ins. deep; one slight crack visible.

Top.—Slab cracked across in two places into about three equal parts, the west-end portion of the slab being the largest, curved downward about ⅝-in.

Bay No. VII. Thames Ballast Concrete.—Soffit.—Curved downwards 1½ ins. in the center in the width. Several bad cracks longitudinally in the slabs, extending over almost the whole area, worst about the center, the cracks being in various irregular directions. Surface damaged all over more than any of the other slabs, greatest depth about 2 ins. and a hole in the northwest corner through which daylight was seen.

Top.—Slab cracked in very many places, cracks being generally transverse or across the slab, but in various diagonal directions as well, no actual longitudinal cracks on upper surface, which are so very marked on the underside, curved downwards about 2 ins. in the width.

Beams.—Portions of the plaster remain on all the beams, but it is badly cracked and flaked. Each beam has part of the concrete washed off where struck by water. No steel work is exposed. The concrete is disintegrated about 1 in. in depth, on the soffit of each, in patches.

Table of Temperatures Taken from Points Nos. 5, 8, 9, 10.

Time. p. m.	No. 5. Deg. F.	No. 8. Deg. F.	No. 9. Deg. F.	No. 10. Deg. F.	Mins. elapsed.
2.5	900	900	920	840	5
2.10	1020	1010	990	1005	10
2.15	1105	1050	1040	1160	15
	(596.1)	(565.5)	(560.0)	(626.6)	
2.20	1040	1050	1030	1100	20
2.25	950	980	990	1000	25
2.30	1020	1040	1060	1040	30
	(548.8)	(560.0)	(571.1)	(560.0)	
2.35	1050	1100	1150	1100	35
2.40	1180	1220	1210	1200	40
2.45	1200	1310	1320	1280	45
	(548.8)	(710.9)	(715.5)	(693.3)	
2.50	1300	1400	1380	1380	50
2.55	1280	1350	1380	1360	55
3.0	1300	1450	1420	1380	60
	(704.4)	(787.7)	(771.1)	(737.7)	
3.5	1350	1440	1500	1420	65
3.10	1310	1405	1450	1400	70
3.15	1320	1440	1460	1410	75
	(715.5)	(782.2)	(793.3)	(765.5)	
3.20	1360	1450	1500	1440	80
3.25	1420	1540	1520	1500	85
3.30	1420	1560	1600	1550	90
	(771.1)	(848.8)	(871.1)	(843.3)	
3.35	1380	1450	1520	1600	95
3.40	1520	1600	1610	1600	100
3.45	1540	1620	1640	1600	105
	(837.7)	(882.2)	(893.3)	(871.1)	
3.50	1540	1600	1640	1620	110
3.55	1580	1620	1620	1640	115
4.0	1580	1630	1660	1660	120
	(800.0)	(887.7)	(915.5)	(904.4)	
4.5	1560	1600	1670	1700	125
4.10	1610	1700	1740	1720	130
4.15	1680	1720	1780	1760	135
	(915.5)	(937.7)	(971.1)	(960.0)	
4.20	1700	1720	1800	1780	140
4.25	1700	1760	1800	1810	145
4.30	1700	1780	1850	1820	150
	(926.6)	(971.1)	(1010.0)	(993.3)	
4.35	1740	1800	1880	1840	155
4.40	1730	1800	1880	1880	160
4.45	1780	1800	1880	1880	165
	(971.1)	(982.2)	(1026.6)	(1026.6)	
4.50	1760	1840	1900	1900	170
4.55	1780	1850	1900	1910	175
5.0	1780	1850	1910	1920	180
	(971.1)	(1010.0)	(1043.3)	(1048.8)	

Degrees in parentheses are Centigrade

A NOVEL USE OF OLD RAILS IN CONSTRUCTING SHOP BUILDINGS.

By D. P. N. Little.*

Some two years ago the Union Iron Works, of Los Angeles, Cal., in looking about for building material for their new shops, found that they could obtain slot rails from an abandoned cable railway in sufficient quantities and at scrap-iron prices. It appeared that a very good column could be made from such rails, using them like Z-bars. These rails were in good condition, showing very little rust. They had ¾-in. punched holes in the base flange, a pair of holes every 3½ ft., and these holes were utilized for making most of the connections. The rails were in 24, 28 and 32-ft. lengths, and the buildings were designed to use them without cutting, except for the traveling-crane columns, for which latter the 32-ft. lengths were cut in two.

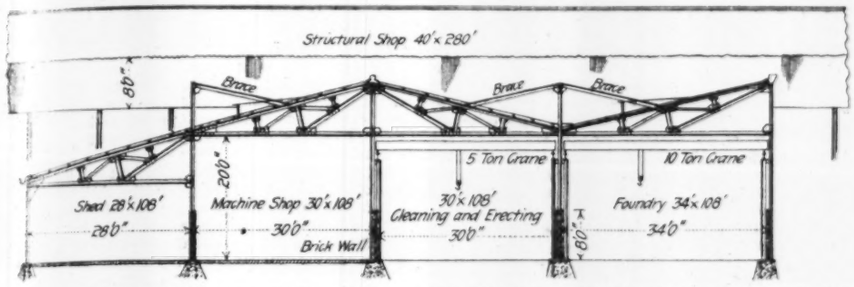


FIG. 1. CROSS-SECTION OF MACHINE SHOP AND FOUNDRY, UNION IRON WORKS OF LOS ANGELES, INC., LOS ANGELES, CAL.

The buildings to be erected were: Structural shop, 40 × 280 ft.; Foundry, 34 × 108 ft.; Cleaning room, 30 × 108 ft.; Machine shop, 30 × 108 ft.; Shed, 28 × 108 ft.; Pattern shop, 48 × 36 ft.; requiring, in all, 109 columns.

The construction of the buildings and the make-up of the columns is exhibited by the two drawings Figs. 1 and 2 herewith. The crane columns are composed of four or six rails, two under each crane girder and two rails to carry the roof load. The other columns are of two rails each. The roof trusses are made of angles, of the ordinary type of riveted roof truss. Owing to lack of head-room over the traveling-cranes, it was impossible to obtain sufficient bracing by gusset plates or angle kneebraces. This difficulty was overcome in all the buildings except the structural shop by extending the columns above the roof, and running kneebrace angles down to the roof trusses.

The group of buildings is in the form of a T, the structural shop running at right angles to the others and being attached to them. The structural building is higher than the others; in this, therefore, the roof trusses were connected to the tops of the columns with gusset plates, and the columns were wind-braced by rods with turn buckles in both the vertical and horizontal planes. The entire structure, being well tied to the other building butting against it, is very strong and rigid. This building extends over the siding of the Santa Fe Railway Co. and enables the traveling crane to unload direct from the cars.

It is interesting to note that all the connections to columns were bolted, and, although the buildings have been subjected to the vibration of machinery and traveling-cranes for two years, on close inspection no loose bolts are to be found.

The roof and sides are covered with No. 26 galvanized corrugated iron, hung to angle purlins by clips riveted to the sheets, which were riveted together at the laps after erection.

It was originally intended to separate the departments by corrugated iron partitions, but as the climatic conditions are favorable, it was finally decided to use brick partition walls 8 ft. high, leaving the space above open. This arrangement has proved very satisfactory, as plenty of light and air is obtained and at the same time no inconvenience is experienced from dust and drafts.

These buildings were erected at remarkably small expense, mainly because of the low first cost of the material for the columns, and the small amount of work required for assembling. All labor, except for the erection of the brick walls and asphalt floors, was done by the structural crew of the company. While aside from the columns there was no particular saving, except from design, it was estimated that the 109 slot-rail columns were erected complete at a price not to exceed $16.00 per ton.

*President, Union Iron Works of Los Angeles, Inc., Los Angeles, Cal.

THE RESISTANCE OF CEMENT AND CONCRETE CONSTRUCTION TO FIRE.*

There is such a scarcity of reliable data and so little actual experience with fires in buildings of any form of concrete construction that any discussion of the subject must of necessity be largely on a theoretical basis, or (at the best) on the basis of laboratory experiment. Both of these, while valuable and necessary, must be supported by actual field experience before the subject can be regarded as properly covered.

In considering the so-called fireproof qualities of cement or concrete it will be well to fix in our minds at the outset the proper definition of the word "fireproof." In a technical sense there is, of course, no such thing as a strictly fireproof building; that is, a building which is absolutely proof against damage by fire. There are, however, many materials which are non-inflammable and capable of resisting or retarding a fire of ordinary intensity for a sufficient length of time to allow the extinguishment of the fire with nominal damage to the structure. Therefore, a building properly constructed of such materials may be entitled to the nominal term fireproof, though, as a matter of fact, the strictly correct term would be fire-resistive. Whether it is practical at this late day to make any such grammatical distinction of terms is doubtful, so that perhaps it will be as well for us to recognize the old term "fireproof," notwithstanding its faults and the fact that in the past it has been the occasion of some misunderstanding and the cause of an overconfidence which has cost many a building owner dearly.

By cement in fireproof construction, of course, we mean generally the Portland cement which forms the vital element in monolithic concrete (plain or reinforced), or concrete block construction; and since cement is always used in connection with the other materials making up concrete of some sort, we may well use the term "concrete construction" in place of "cement construction."

That good concrete is a fireproof material in the above defined sense is a well-established fact, as has been demonstrated in a limited way by tests in laboratory and field. Most of the laboratory trials have been made with small buildings 10 to 15 ft. square, heated to 1,700 or 1,800° with wood or gas fires for two to three hours' time. Such a test, while not calculated to demonstrate the ultimate fire resistance, is thought to approximate the ordinarily severe fire which may be expected in most kinds of buildings. Good concrete has successfully passed these tests, and the occasional failure of poor material under the same trial has taught some valuable lessons.

The field experience is more difficult to summarize. The first case in mind is generally the great Baltimore fire, in which were several small buildings involving more or less concrete construction, all of which came through the fire very well, though the conditions were somewhat favorable, in that the fire in each individual building was of short duration and no water was played on the building while hot. The Iroquois Theatre fire, in Chicago, was another case of a concrete building suffering very little damage, but in this case also the fire was of very short duration and the test therefore very mild. The Pacific Coast Borax Co., Bayonne, N. J., suffered a severe fire about four years ago in a building all of concrete except the wooden roof. In this case the test was very severe in the upper part of the structure, and the damage to the concrete very trifling—a good test with remarkably good results. Other fires of less prominence have occurred with similar results.

Considering first reinforced concrete: In order to be fireproof in the accepted sense, the concrete itself must possess two important qualities—1, it must be capable of withstanding such disintegration or breaking as would either diminish its own strength or expose to fire the steel reinforcement; 2, it must effectually insulate the imbedded steel reinforcement from the heat of a fire, even when not broken down.

There are several factors affecting the first of these requirements—the stone or other aggregate must not lose its strength or break or fly in pieces readily. In this particular there is doubtless some difference between the various aggregates commonly used, though we have only a limited amount of data bearing on this point. The National Fire Protection Association's Committee on Cement for Building Construction conducted a series of experiments a few months ago which afforded a comparison between limestone, gravel which contained a considerable proportion of lime, granite and cinders. These tests showed practically no breaking or spalling of the concrete, but the conditions were favorable to such result, in that the samples were rather small and were so arranged in the test furnace that throughout the test they were free to expand in all directions, and the individual stones of the aggregates were of small size, not larger than ¾-in. Analysis of numerous tests by the New York Building Department, the British Fire Prevention Bureau and other sources also fails to reveal any decisive difference in fire resistance of various concretes due to difference in the kind of aggregates in common use. The latest test of this which has come to our notice was made last October by the British Fire Prevention Bureau, which included simultaneous trial of seven small slabs of 1 : 2 : 3 con-

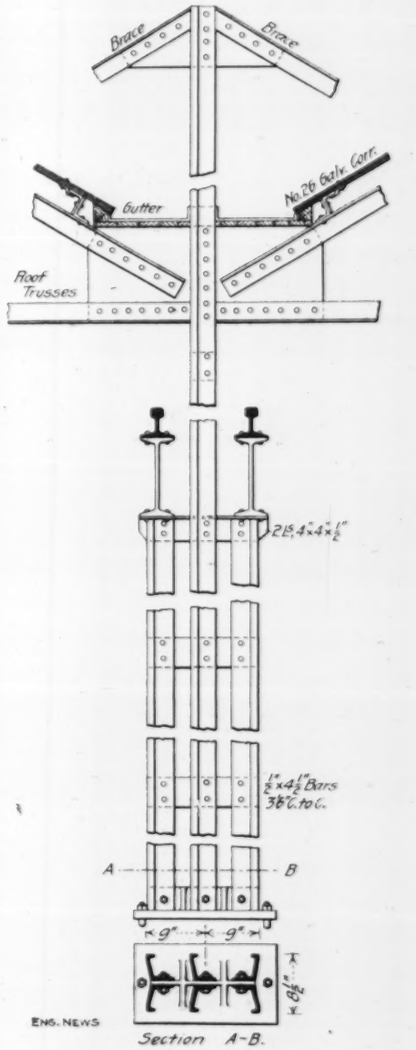


Fig. 2. Detail of Crane Column Between Foundry and Cleaning-Room.

*Abstract of the report of the Committee on Fireproofing and Insurance, presented at the annual meeting of the National Association of Cement Users, at Milwaukee, Wis., Jan. 9-12. The report was prepared by Mr. E. T. Cairns, Chairman of the special committee on Cement for Building Construction of the National Fire Protection Association, Chicago.

crete of different aggregates, described as slag, broken brick, coke breeze, furnace clinker, granite, burnt ballast and Thames ballast, the relative efficiency from high to low being about in the order named. Two of these—furnace clinker and Thames ballast—were quite deficient, but the others did not differ widely, and the result was similar to that obtained in many other tests; that is, some small cracks developed and in some cases the material was washed off by hose streams to a depth of an inch or so, but none of the slabs broke down.

It is the opinion of many that granite or any stone containing a relatively large percentage of water crystals is most objectionable, as it has a tendency to burst as the crystals are decomposed, this danger being obviously greatest where the individual stones are of a large size; and the use of such stone in concrete is therefore objectionable.

Limestone has been criticised as an aggregate on the ground that it is calcined or reduced to powder quickly under high temperature. It is true that it does lose its strength in this way more easily than most other stones, but this committee is of opinion that the stone does not weaken much, if at all, before the cement which binds the units together; so its weakness is not really such an important matter as might at first appear. It is probable that trap rock, a hard, dense stone found in some Eastern States, or silicious gravel, or strictly clean clinker, make the most desirable aggregate from the fireproof viewpoint, though the latter, being practically unobtainable in sufficient quantities, makes a recommendation for its general use unwise. The kind of sand or its state of purity or sharpness is thought to affect the fireproof qualities of concrete only as it affects the normal strength of the material, and therefore the factor of safety upon which the endurance of the structure under fire largely depends.

It is very evident, of course, that the integrity of concrete under exposure to fire, as well as under normal conditions, depends primarily on the cement which binds the mass together; and in this fact lies the most important inherent weakness of concrete as a fireproof material. As to the fireproof qualities of Portland cement itself, very little information appears to be available. The standard specifications adopted by the American Society for Testing Materials, the American Society of Civil Engineers and others does not touch on the point at all, possibly for the reason that some have assumed that cement which meets the other requirements as to strength, soundness, etc., cannot vary much in fire resistance, and perhaps for the reason that a very large part of the cement for which these specifications are prepared is used in bridges, embankments, marine work, etc., where fire resistance is not a factor. Neither do the U. S. Army Engineers, nor various foreign specifications, cover the point, probably for the same reasons. Cements which conform to the standards above referred to cannot vary much in the proportion of their chief constituents, though some of the minor elements do vary considerably; and it is well known that there is quite a wide difference between various brands as to the quantity of water required for hydration, and it may be these differences, especially the latter, may have an important bearing on the fire resistance. Various experiments now under way will doubtless settle the question within the next year or two, but for the present we must assume that all Portland cements conforming to the accepted standards in other respects are of equal fire resistance.

The statement so often made that cement is necessarily fireproof because in the course of its manufacture it has been burned in a kiln hotter than any burning building is not true any more than is the same statement concerning hollow tile or other materials. They both appear in a building under radically different conditions than obtain in any sort of a kiln, the important difference in the case of cement being that when mixed into a concrete it is combined in a crystalline form with water, which is a material very easily affected by heat. There is no occasion for discussing here the intricate question of the chemistry of cement. It is sufficient to say that the effect of heat is to dehydrate it or separate the water from the cement, and thus reduce it to a condition resembling its original powdered state. The temperature at which this dehydration occurs is probably about 1,000° F.—that is, the cement itself must reach that temperature—but concrete being a slow conductor of heat, any considerable mass of the material cannot absorb that amount of heat for some time after the temperature at its surface has reached the 1,000°, or even a very much higher point; hence it is that in a burning building a temperature of 1,000° to 2,000° may be applied suddenly to the surface of a concrete wall or floor, and the result will be an immediate dehydration of only a very thin film of cement at the surface and a very slow progression of dehydration into the interior of the mass. As above stated, this dehydrated or re-calcined material does not necessarily fall away unless struck by a stream of water or other object, or unless the rupture of individual stones in the concrete throws it off; and so long as it remains in place it acts as a very efficient insulator for the remaining good concrete beneath, so that the penetration of heat into the mass and its consequent dehydration grows slower and slower. If by this process the cement loses its adhesive strength, of course the concrete is ruined, and in the case of walls or columns its crushing strength is reduced in the proportion that the dehydration of the cement has penetrated from the surface, and this is irrespective of the kind of aggregate used. The logical conclusion of the above is that, given a cement and aggregate of good quality, the fire resistance of a concrete wall or floor is entirely a question of the time of exposure and temperature of the fire.

Whatever the comparative value of various aggregates or cements may be, a far more important factor in the strength of concrete under fire, as well as under normal conditions, is the relative proportion of the materials and the method of combining them. The necessity of a dense, fairly rich concrete, practically free of voids, such as is produced by a wet mixture well tamped, is well known to all experienced users of the material, and the troubles occasioned by mixtures containing too little cement, or made too dry, or not properly tamped, are perhaps too familiar to some of us. This feature has a direct bearing on the fire resistance of the structure, as a dense, rich mixture is much less liable to spalling and disintegration than a poor, porous concrete; and if the theory is correct that the dehydration of the cement itself or the driving off of its water is what weakens the mass, then the richer in cement the mixture is, and consequently the more water is contained in the mass, the longer the cement will last, because a longer time will be required to drive off the large amount of water. Furthermore, its factor of safety above the strength required for normal conditions is naturally much greater, and that has a most important bearing on the fire-resistance feature. A structure so built that a considerable proportion of its ultimate strength may be destroyed by fire without causing a collapse obviously has a much greater chance of escaping total loss than one which, though non-inflammable, has no great strength above that required for normal conditions; and so would be subject to collapse on the failure of some one or two of its vital members. The abnormal strains to which a building is subject during a fire are always severe, and often not to be determined in advance. The falling of heavy weights and internal stresses set up by rapid changes of temperature are severe trials to any building, and the structure that contains the greatest reserve strength above that required for ordinary demands is the safest. This, of course, refers to any type of construction, as well as to concrete, and the disregard of this principle has in many cases cost dearly in case of fire. In the famous Baltimore conflagration the great weakness of tile and steel construction was along this very line; the tile was good enough for its normal uses, but was generally too thin and frail and too poorly secured in place to withstand the mechanical strains imposed by a severe fire.

As to the second general requirement of insulating quality of concrete for the steel reinforcement, the importance of this function of the material is apparent when we remember that in practically all reinforced concrete construction the steel, of whatever style or system, is designed for the vital duty of carrying all the tensile strains of the structure, and in order to do this it must be placed as low as possible in the beam or slab; in fact, there is no reason, structurally, for more than barely covering the rods. It is well known that steel loses its strength very rapidly on exposure to fire, and steel of any form used as a reinforcement for concrete is no exception to the rule. According to Kent, the tensile strength of steel at 670° is only 75% of its ultimate strength under normal temperature; 60% at 725°, 50% at 770°, 40% at 860° and 30% at 1,025°. From this it is obvious that the reinforcement of a concrete floor beam, slab, column or wall must have some very efficient insulating material between it and an ordinary fire if its strength is to be retained. It is well known that concrete is a very slow conductor of heat, but there are only a few exact data on the subject. The tests of the National Fire Protection Association committee, above referred to, were chiefly for the purpose of determining that point, and showed that on an average of 11 sample rods embedded to a depth of 1 in. in concrete reached a temperature of 670°, where their strength is reduced 25% in 59 mins. under average temperature of about 1,500° at the surface of the samples.

This would appear to afford ample proof that 1 in. of concrete covering over steel reinforcement or about steel I-beams is not sufficient for reliable fire protection. In many large buildings, particularly of mercantile or storage occupancy, temperatures of 1,800° to 2,000° may prevail in portions of the structure for much more than an hour, in which case 2 ins. or more of protection would be necessary to preserve sufficient strength in the steel to carry its load. This would be true even if all the concrete were certain to remain in place during a fire, and, with the possibility of some of the material breaking off the extra thickness, is doubly necessary. As to the relative value of the various kinds of aggregate as an insulator, none of the numerous tests referred to indicate a very wide difference, but such variation as does appear is in favor of the cinder aggregate and most unfavorable to the granite. Here again the superiority of a rich, dense concrete appears, as the tests indicate that as between rich, medium and lean mixtures the richer mixtures were appreciably slower conductors of heat than the lean ones.

The fire resistance of concrete blocks for wall construction has been the subject of much anxious inquiry for some months past. The question is being investigated by several interests, but probably most exhaustively at the Structural Materials Testing Laboratory at St. L[illegible] by Mr. Richard L. Humphrey (President of this Association) under the auspices of a general advisory board composed of representatives of a large number of engineering bodies, including this Association and Government officials. The result of this and other investigations, of course, cannot be foretold, and the actual field experience with this construction thus far is too limited to afford a basis for positive conclusions. However, we are confident that most of the foregoing statements on the subject of concrete in general are applicable to concrete blocks of the same materials. The form in which some of these small blocks are made involves a certain weakness under severe temperature, which, while by no means fatal to the fire resistance, places a limitation on the quality which must be recognized, viz.: it is subject to breakage by unequal expansion under heat, the same as is hollow tile or any other similar hollow material. Hollow blocks of concrete or tile, as set in the walls or floors of a building, usually present only one surface to the direct attack of fire, and the consequence is that that side or face of the block expands readily and irresistibly under the influence of the heat, while the other three sides, receiving much less heat, do not expand nearly as rapidly, with the result that the hottest side breaks away from the others. This has been demonstrated in actual fires and experimental tests for both concrete and tile. Failure from this cause would naturally occur soonest in blocks having a thin shell, inasmuch as the thinner the shell of the block toward the fire the more quickly it will heat through, and consequently expand. Therefore, if you would have a block stand a hot fire, make the webs thick.

This breaking by unequal expansion has sometimes been referred to as a bursting due to pressure of steam or gases generated in the large hollow space or cell of the block, but a very brief analysis of the conditions will easily disprove any such statement. In the first place, there is generally no means of getting water into the interior of a block and no probability of gases from other sources being introduced therein; but if it were possible to get gas or steam into the interior space these cells are so continuous in a wall or floor and have so many vents to the atmosphere at the top of the wall or through mortar joints that the accumulation of pressure (estimated at 25 to 50 lbs.) necessary to burst an ordinary small block would be an impossibility under working conditions. In connection with blocks, we may repeat that, as in the case of monolithic concrete, good materials, plenty of cement, careful curing, and, above all, intelligent workmanship, produce the most fireproof result.

To sum up this matter of the fire resistance of concrete, we may repeat that, while, like all other building material, it has its limitations, it occupies, and will continue to occupy, an increasingly important position in the field of fire resistive construction, and when intelligently used, under proper conditions, may be relied on to resist such fires as any ordinary building may be expected to experience. Such intelligent use will involve the selection of good materials, will provide for the correct and uniform proportioning of them, the thorough mixing by good machinery, adequate thickness of insulation of steel, guarding against freezing, and, in the case of blocks, proper curing and thickness of shell; in short, all the requisites of a building safe and strong under normal conditions with a liberal factor of safety. It may be safely assumed that concrete which is the richest, strongest and most durable under normal conditions will develop the highest fire resistance.

The relation of fire insurance to concrete construction is important to insurance companies and builders alike. The attitude of the companies toward concrete up to this time has been, like that of other interests, necessarily one of inquiry and investigation largely. They have felt that this type of construction was in an experimental stage, acknowledged as peculiarly subject to abuse by incompetent users, and have naturally been somewhat cautious in indorsing it as fully as its advocates would like. They are now recognizing, however, that the matter is rapidly approaching a settled and known basis in the building world, and they are at the present time according it more recognition in their underwriting than ever before. Insurance companies are the most earnest advocates of improved construction, and are constantly urging the adoption of the best known methods and materials for building. They are investigating the whole concrete subject through the National Fire Protection Association and other channels, and there need be no doubt that concrete construction will be given full credit in fire insurance rates and classifications for all its good qualities as soon as its record is established. In the meantime they are giving very liberal credit to so-called fireproof buildings of concrete construction, practically the same as are allowed for other types, as a rule. They are not, however, recognizing concrete blocks as the equivalent of good brick, for the reason that such experience as they have had in laboratory and field does not warrant it. This is no doubt due partly, if not chiefly, to the fact, familiar to us all, that a large proportion of the blocks made up to this time have been of an inferior grade, made without due regard to the known require-

ments of a good product; and, in the matter of insurance rates, as in other respects, good material has been made to suffer for the failings of the too large proportion of poor material.

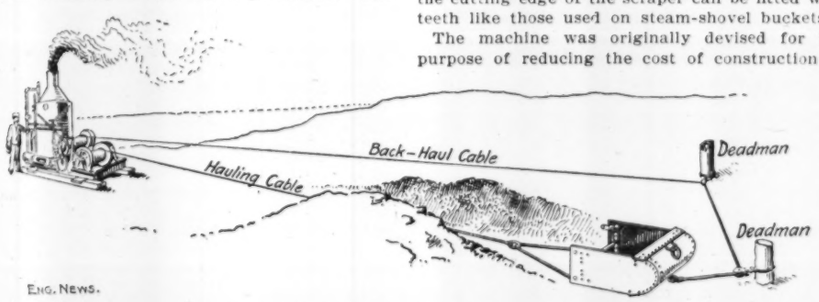
In closing, we cannot too strongly emphasize the fact that the position concrete is to occupy in the art of fireproof construction will depend very largely on the degree of intelligence and honesty of its users. It has had something of a fight to attain its present position. It is not a new proposition. For years it has been known, and for as many years has been criticised as being peculiarly subject to abuse by incompetent contractors—a criticism which we must admit is altogether too well founded, and for which some of its most ardent advocates are partly responsible. There will always be more or less such criticism, but it can be largely overcome and the art maintained on a sound basis by the intelligent and persistent following of sound engineering principles and good workmanship on the part of its advocates.

The time has not yet arrived for adopting a detailed standard for fireproof concrete construction, but we would commend to you a few fundamental principles which were laid down by the National Fire Protection Association in their last report as essential to the best results:

1. The work should invariably be designed and its entire erection supervised personally by engineers of skill and experience in this particular line.
2. Concrete for fireproof construction should be composed of high-grade tested Portland cement, clean sand and broken stone, gravel, slag or cinders, so proportioned that the cement will completely fill all the voids in the sand, and the mortar thus formed will a little more than fill the void in the aggregate.
3. The materials should be well mixed by machine, with enough water to make a distinctly "wet mixture," and should be tamped down so that no voids are left.
4. All steel members of whatever style should be imbedded at least 2 ins. in the concrete, and 3 ins. in the case of important load-carrying members.
5. No cement work of any kind should be laid in cold weather without being safely guarded against freezing.

A POWER SCRAPER FOR GRADING AND EXCAVATION.

Power scrapers operated by cables and hoisting engines have been employed for grading and excavation work in a number of cases, and have proved successful in regard to both the cost and general efficiency of the work performed. The



A POWER SCRAPER FOR GRADING AND EXCAVATING.
Bagley Grader Co., Tacoma, Wash., Builders.

Hammond machine (Engineering News, Oct. 20, 1904), has a combination of drag and wheel scraper which is equipped with mechanical appliances for dumping, etc., and is handled by lines running to the engine and an anchor, or deadman. The Page machine (Engineering News, March 2, 1905) has a plain drag scraper, which is handled from a derrick boom, so that the length of haul is limited. The Bagley machine, described below, has a plain scraper, which is operated by lines arranged in a somewhat different manner from those of the Hammond machine.

The Bagley grader has a bucket or scraper of box shape, with the rear end rounded, while at the bottom of the open front end are a spreader brace and a triangular bail. The scraper is of ⅝-in. or ¾-in. steel plate, and has riveted at top and bottom a transverse knife of ¾-in. steel, 10 ins. wide. The object of using two knives is that when one becomes blunt the scraper can be reversed and work continued, the knives being sharpened at night. To the bail is attached the 1-in. steel hauling cable, which is led to the front drum of a double-drum hoisting engine. To a ring at the back of the scraper is attached the ⅞-in. back-haul rope, which is passed through blocks attached to two deadmen (or trees) and thence back to the rear drum of the engine. This forms a triangular arrangement, as shown in the accompanying cut. The 3-yd. scraper is 6 ft. long, 5 ft. wide and 2 ft. 6 ins. deep, with knives 5 ft. 6 ins. long; the 6-yd. scraper is 8 × 7 × 3 ft., with knives 7 ft. 6 ins. long. The smaller one requires an engine with cylinders 9¼ × 10 ins.; while an engine with cylinders 10 × 15 ins. is required for the larger one. Of course, the actual capacity depends somewhat upon the class of material handled. It is recommended that the length of haul should not exceed 1,500 ft., and the scraper can be diverted from its regular course by means of lead blocks, if required. It is claimed that the machine can handle any soil in which the rocks or boulders do not exceed 20 ins. in size, and that it is not necessary to plow the ground, the knife being placed at such an angle that the weight of the scraper forces it into the soil. If the soil is very hard or contains many rocks, the cutting edge of the scraper can be fitted with teeth like those used on steam-shovel buckets.

The machine was originally devised for the purpose of reducing the cost of construction of the Tacoma Eastern Ry. It is stated that the lowest outside bid for grading was 35 cts. per cu. yd., while with this machine the cost was from 5 to 10 cts. per yd. For ordinary grading, one machine, with a crew of five men, will do the work of 15 to 30 scraper teams, according to the conditions. The machine is also used for loading ballast, and it is stated that it will load a 60,000-lb. hopper bottom ballast car in about three minutes, with a haul of 300 ft. About 30 machines have already been sold, and are being extensively used on the Pacific coast for railway grading (excavating cuts and building banks), especially on logging roads. The Polson Logging Co. reports that it has made a cut 34 ft. deep and 800 ft. long in cemented gravel and soapstone "at one-quarter of the expense of the old-fashioned way."

The machine was invented and patented by Mr. John Bagley, Vice-President and General Manager of the Tacoma Eastern Ry., and is built by the Bagley Grader Co., of Tacoma, Wash.

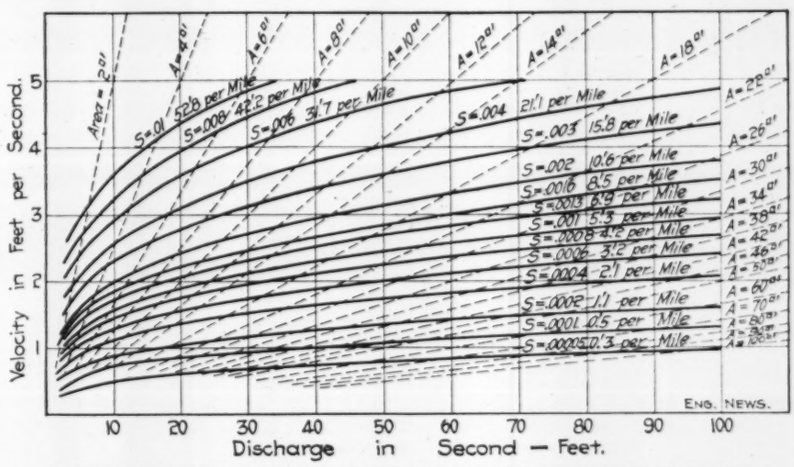


DIAGRAM FOR USE IN LAYING GRADE LINES ON SMALL IRRIGATION CANALS.

A DIAGRAM TO AID THE LOCATION OF SMALL IRRIGATION CANALS.

By Paul McGeehan.*

The accompanying diagram and table have been used for laying the grade lines on the smaller irrigating ditches of the Klamath Project of the U. S. Reclamation Service, and may be interesting to some of the readers of Engineering News.

The curves are platted from tables showing longitudinal slopes of canals having geometrically similar sections, but carrying varying quantities of water at different velocities. The curve calculations were made by a slide rule with the aid of Flynn's table of Kutter's formula. They were made for side slopes of 1½ to 1, and bottom widths equal to twice the depth of water. They are sufficiently accurate for bottom widths equalling the depth or three times the depth; the error for the smaller canals is insignificant. The diagonal lines of the diagram represent areas of canal sections, and were platted from the straight line formula, $Q = A\,V$. In the table B = Bottom width of canal, and D = Depth of water.

By allowing a given width for the crown of the embankment, and a given distance from the crown to the water surface, the vertical distances from the surface of the ground to the surface of the water is practically constant: that is, if it is desired to make the excavation equal the embankment. This does not apply to all canals,

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TABLE FOR LAYING GRADE LINE ON SMALL IRRIGATION CANALS.

Area.	B = D		B = 2D		B = 3D		Crown	Height of W. S.			Excavation
	Bottom.	Depth.	Bottom.	Depth.	Bottom.	Depth.	width.	below crown.	below ground.	above ground.	per mile.
Sq. ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Cu. Yds.
2	0.89	.....	1.51	0.75	2.00	0.66	2	1	0.4	.....	720
4	1.26	.....	2.14	1.07	2.83	0.94	2	1	0.2	.....	970
6	1.55	.....	2.62	1.31	3.46	1.15	2	1	0.1	.....	1,240
8	1.79	.....	3.02	1.51	3.99	1.33	2	1	0.0	0.0	1,530
10	2.00	.....	3.38	1.69	4.47	1.49	3	1	.....	0.1	1,870
12	2.19	.....	3.70	1.85	4.89	1.63	3	1	.....	0.2	2,060
14	2.37	.....	4.00	2.00	5.28	1.76	3	1	.....	0.2	2,285
18	2.68	.....	4.53	2.26	6.00	2.00	3	1.5	.....	0.1	3,240
22	2.97	.....	5.01	2.50	6.64	2.21	3	1.5	.....	0.2	3,700
26	3.23	.....	5.45	2.72	7.20	2.40	3	1.5	.....	0.3	4,200
30	3.46	.....	5.86	2.93	7.74	2.58	4	1.5	.....	0.3	5,020
34	3.69	.....	6.23	3.11	8.25	2.75	4	1.5	.....	0.4	5,880
38	3.90	.....	6.59	3.29	8.73	2.91	4	1.5	.....	0.6	5,750
42	4.10	.....	6.92	3.46	9.18	3.06	4	1.5	.....	0.7	6,110
46	4.29	.....	7.25	3.62	9.60	3.20	4	1.5	.....	0.8	6,500
50	4.47	.....	7.56	3.78	10.02	3.34	4	1.5	.....	0.8	6,900
60	4.90	.....	8.28	4.14	10.95	3.65	5	1.5	.....	0.9	8,200
70	5.29	.....	8.94	4.47	11.85	3.95	5	2	.....	1.0	9,750
80	5.65	.....	9.56	4.78	12.66	4.22	6	2	.....	0.9	11,580
90	6.00	.....	10.14	5.07	13.41	4.47	6	2	.....	1.1	12,560
100	6.33	.....	10.68	5.34	14.13	4.71	6	2	.....	1.3	13,500

NOTE.—Computation on basis of B=2D.

but is sufficiently close for practical purposes for the small canals herein considered.

The column headed "Excavation per mile" is principally useful for purposes of comparison. However, it is usually economical to locate small ditches on a "grade contour," and often it is possible to predict quite accurately the amount of earthwork to be expected.

Suppose, for instance, that the quantity of water to be carried is 60 sec. ft., and the velocity to be 2 ft. per sec., the grade will then be, by interpolation, .00055, and the area from the diagonal lines will be 30 sq. ft. Finding Area 30 in the table, and noting the different depths which can be used, the grade should be laid so that the water surface will be 0.4 ft. above the ground, and the quantities per mile will be 5,380 cu. yds.

In the Reclamation practice here water is to be delivered at some point on each quarter section at an elevation great enough to command the land. Between these points an economical location is desired, and it is often possible to change the grade every few hundred feet. I have found a rapid method of determining the effect very convenient.

Of course, the above applies to clear water, and the curves will be of less value when the water carries silt.

DECISION ON APPEAL IN THE MANHATTAN BRIDGE CONTRACT CASE.

Two months ago, in our issue of Nov. 30, 1905 (p. 580), we presented a very interesting court decision on a large public contract, which decision touched questions likely to occur in many, if not most, public works contracts. The decision was rendered by Justice Dowling, of the New York State Supreme Court, and dealt with a proposed contract between the City of New York and the Pennsylvania Steel Co. for furnishing and erecting the superstructure of the Manhattan Bridge over the East River, New York City. It continued a temporary injunction granted against the parties to the proposed contract on application of one Gage, a taxpayer and secretary of the John Pierce Co., who bid $200,000 more on the work than the Pennsylvania Steel Co. Appeals were taken by the two defendants to the Appellate Division of the Supreme Court. This court rendered its decision two weeks ago, confirming the lower court and declaring the proposed contract illegal. The opinion of the higher court has just become available, and we reprint its essential parts below.

The principal clauses of contract form and specification which are involved in the decision were given by us in the issue above cited in connection with the opinion of the lower court, and they should be referred to in reading the present decision. In addition, the following extract from the charter of the City of New York is to be noted:

(Section 419). Whenever any work is necessary to be done to complete or perfect a particular job, or any supply is needful for any particular purpose, which work, or job, is to be undertaken or supply furnished by the City of New York, and the several parts of the said work or supply shall together involve the expenditure of more than $1,000, the same shall be by contract, under such regulations concerning it as shall be established by ordinance or resolution of the Board of Aldermen. * * *

Section 346 of the city ordinances specifies in regard to the manner of letting work:

The proposals for estimates shall be in such form as may be prescribed by the department making the same, and shall contain the following particulars * * * ; They shall state the quantity and quality of supplies, or the nature and extent, as near as possible, of the work required.

These provisions, which the court characterizes as indefinite, are amplified by previous decisions of the courts in a manner which is accepted and upheld in the present decision. The following reproduces the main parts of the opinion:

Peter A. Gage, respondent, v. The City of New York, George E. Best as Commissioner of Bridges, etc., and the Pennsylvania Steel Company, appellants.

Laughlin, J.— * * * * * * * The provisions of the statute and ordinance with respect to the preparation of plans and specifications are very meager. Ordinarily the legislature incorporates in municipal charters a provision requiring the preparation in advance of definite plans and specifications as to work which is required to be let by public competitive bidding, but this does not appear to have been done concerning the City of New York. The courts long ago, for the protection of the public, were obliged to spell out of these somewhat indefinite provisions a requirement that there should be plans and specifications with reasonable definiteness, and in the various amendments and revisions of the charter clear and definite express legislation does not appear to have been enacted. The original provisions were re-enacted subsequently substantially as they existed, and for their true meaning recourse must be had to the decisions of the courts, for literally the ordinance would seem to provide that the *bidder* is to furnish the plans and specifications. The courts have, however, held that plans and specifications of sufficient definiteness *to require competition on every material item* are required and must state the quantity of work required as definitely as is practicable (Matter of Merriam, 84 N. Y., 596; Matter of Rosenbaum, 119 N. Y., 24; Matter of Anderson, 109 N. Y., 554). Definite plans and specifications are necessary to insure the economical performance of the work by getting the best results from competitive bidding. Another object of letting public work to the lowest bidder, after inviting public proposals, is to prevent "favoritism and jobbing" on the part of public servants intrusted with authority to make contracts for public work and supervise the execution thereof (Brady v. Mayor, etc., 20 N. Y., 316).

The learned counsel for the defendants very properly drew attention to the magnitude and complexity of this work and to the disastrous consequences in the destruction of life and property that may attend any mistake or error with respect to the nature of the material used or the workmanship in the construction of the bridge. Attention is also drawn to the fact that this contract is only for the superstructure, which is to be erected on columns of masonry already constructed under another contract, and that in some instances in the past it has been found that the foundations of bridges were insufficient to support the superstructure or gave way thereunder. We are admonished that unforeseen accidents of this or a like nature are possible and are very properly asked to examine the specifications, drawings, proposal and contract having those things in mind.

Counsel for the plaintiff urges that the contract is invalid on account of the alternative provision of paragraph 254 of the specifications, with respect to whether high carbon steel or nickel steel shall be used for certain parts of the work therein specified. This provision is somewhat blind as to who has the election and is to decide which material shall be selected. It appears by the affidavit of one of the experts presented by the defendants that he had charge of the examination of the specifications, drawings and contract and of the preparation of a bid by one of the five who submitted a proposal for the work; and that he understood and interpreted the provision as giving the option to the contractor. The plaintiff, however, alleges and the successful bidder now concedes—the learned judge at Special Term, as stated in his opinion, understood its counsel to contend otherwise, notwithstanding the fact that its general superintendent assisted, as one of the commission, in preparing the specifications and contract—that taking the contract and specifications as a whole, although there is no express provision on the subject, the apparent intention was to give the option to the commissioner of bridges. The specifications and contract not being definite or clear on this point, it will be still open to the contractor to claim that the election rests with it, and the engineer will be free to so interpret them. Thus, regardless of which may be the better material, the contractor may be permitted to use that which is the cheaper.

It appears that this material will not be needed for two years after the contract is let, for the reason that the anchorages, steel towers and steel cables, also embraced in this proposed contract, must be constructed or substantially constructed first. It was shown on behalf of the plaintiff that the present market price of nickel steel, such as required by these specifications, is from $30 to $35 per ton more than that of high carbon steel. The specifications prescribe the requirements for both kinds of steel, but neither the quantities nor the dimensions are therein shown or stated; and for these reference is made to the drawings *which it is conceded* only represented the dimensions and quantities that would be necessary if nickel steel should be used. It appears to be conceded that if high carbon steel is used a greater quantity will be required to make as strong and durable a bridge; but it does not appear (not clearly, at least, as it should, as will be shown presently) either by the contract or specifications that the contractor shall furnish the larger quantity of high carbon steel required without extra charge if that material should be selected. The defendants show by affidavits that if nickel steel is used only 16,247,000 pounds will be required, while if carbon steel is used 19,408,000 pounds will be required. There is at present, as has been seen, a great difference in the cost of the material—over a quarter of a million dollars—assuming that the same quantity only is required to be furnished, and a very considerable difference even if the larger quantity of carbon steel must be furnished; but it is conceded that on account of the greater bulk and weight, if the larger quantity of carbon steel should be required, the cost of handling it, including transportation and placing in place, will be more than if nickel steel is used. It is claimed on behalf of the defendants, and many affidavits are presented tending to show that taking into consideration the fact that if high carbon steel is used a larger quantity will be required, the handling of which will cost more, and more work will be required because the holes for rivets must be drilled, whereas part of them may be punched in nickel steel, and that the inspection of the material while in the process of manufacture will necessarily be very rigorous—the extra cost of nickel steel over high carbon steel would not be more than $7,721 to $10,000. On the other hand, the plaintiff presents affidavits of certain engineers, with less apparent technical education and experience than those offered in behalf of the defendants, tending to show that the additional cost of nickel steel over high carbon steel, even if the contractor should be obliged to furnish the increased quantity of the latter, figured on the present prices, would be a very large sum, approximating $120,000. It is evident that the difference in cost of material and construction would be much more if the contractor were obliged only to furnish the same quantity of high carbon steel as if nickel steel had been required. The reason assigned by the professional experts for not now definitely specifying one or the other of those materials is that it has only recently been discovered that nickel steel is probably a superior material for this purpose to high carbon steel, owing principally to the fact that greater strength is given with less weight and bulk, but that it is still somewhat experimental and has not had a satisfactory practical test for work of this character. The commissioner testifies that in connection with the construction of the Blackwell's Island Bridge he is having tests made of the relative value of these materials for this purpose; and that within two years, and before the use of such materials becomes necessary, the result of those tests will be known. That would seem to be a good reason for postponing the letting of this part of the contract if that be reasonably practicable. It is not claimed that there would be any insuperable difficulty in awarding it separately, even if another contractor should be the lowest bidder. It is, however, claimed that it would be quite inconvenient to have another contractor employed on the work toward the finish, that being the time when the authorities contemplate having this high carbon or nickel steel work proceed. That seems reasonable and justifies letting the work together to the same contractor, and manifestly that course is advisable if it may be done legally and without detriment to the interests of the city from a financial standpoint.

It would have been competent in these circumstances to have so framed the specifications and drawings as to show separately the quantity of material required if high carbon steel should be selected and the quantity that would be required if nickel steel should be adopted, and then to have the bidders specify separately the amount for which they would furnish either material and do the work. It is not claimed that there would be any legal objection to this method or that it would be impracticable. It would be fair alike to the city and the contractor. It may be that no contractor would be the lowest bidder on the whole work whichever of these materials should be used; but, if not, some other plan could be devised for changing the specifications or invitations for proposals, so that it could be determined which proposal is lowest. However, if the contract could not be legally let after inviting proposals with separate estimates on these different kinds of material because it could not be determined who was the lowest bidder, it seems quite clear that resort to the method that has been adopted could not be bad for the purpose of removing the illegality. That would be merely covering it up.

It is not a case where it is essential that the city should know in advance the total cost of the work, as if a local assessment were to be made to defray the expense. Under the provision of the specifications forming part of the proposed contract, a successful contractor could not avail himself of the present market price and presently contract for the material. This could only be done with safety after the commissioner decides which material he will require; and that decision may not be made for two years. It has been sufficiently and satisfactorily shown that at the present market prices of the material there is a substantial difference between the cost to the contractor of the two kinds of material, and that there may be a like greater difference when the time for the use of the material arrives. It will then rest with the commissioner of bridges to decide which material the contractor shall use, or he may leave it to the contractor. If he interpret the specifications as giving him the right to decide, he may in good faith decide that the cheaper material is the better, and the contractor will reap the benefit, with no rebate to the city. The difference between the cost of these materials may then be very

great. The greater the difference in cost to the contractor the greater the incentive to improperly influence the public officials in deciding on the material the contractor shall be required to use or in leaving the choice to the contractor. Thus we have presented a situation which it has always been one of the objects of statutes governing the letting of public work on competitive bidding by public proposals to avoid. *We have shown that it was unnecessary* to frame this provision of the specifications in the alternative which necessarily required bidders to figure on the cost of construction with the most expensive of the two materials as the basis for their proposals. We do not wish to be understood as reflecting on the good faith of the public officials in this matter. This decision is to become a rule of law, not merely for the government of the present officials, but for all time while the statutory law remains the same. If we should sustain this provision of the specifications the door would be opened to collusion between public officials and intending bidders by which one or more of the bidders might know in advance which material the officials would require under the alternative provision of the specifications and thereby obtain an undue advantage.

Moreover, if the contract should be awarded on the proposal of the Pennsylvania Steel Co. a very serious question might arise as to whether it would be obliged to furnish more high carbon steel, if that material should be adopted, than is required by the drawings. We do not find that the drawings specify that they are for nickel steel, and it is not apparent that bidders would know whether they are for nickel steel or high carbon steel. That, however, is not the material point. It seems to be conceded that the dimensions and quantities shown by the drawings, so far as they relate to the work to be constructed of either high carbon steel or nickel steel, are the dimensions and quantities essential if nickel is used. * * * * * * * * * * * * * * * * * * (But) there seems to be no clear, if any, requirement, even in the specifications, that if high carbon steel is used that part of the chords, chord splices, diagonal web trusses and gusset plates which paragraph 254 provides shall be constructed of either nickel steel or high carbon steel, shall be enlarged or increased in number to attain the same strength as would be afforded if nickel were used according to the drawings. It is evident that new drawings would be required if carbon steel should be used *and* these parts should be thus enlarged. The form of proposal pursuant to the provisions of the ordinance quoted in the statement of facts required bidders to specify the quantities of the different material upon which they submitted estimates giving the unit and total price on which they figured in making up their bids. The blank forms of proposal so far as material on this point contained four columns. The first was headed "class of work," and under this was printed in separate items a general description of the work called for, and, among others, "nickel steel or high carbon steel riveted work, pounds." The second column was headed "Total quantity." It was blank, but the defendant steel company filled in the figures "16,247,400," which is the quantity required to comply with the drawings. The third column was headed "unit price," and in that the bidder filled in ".0878," which evidently means the price per pound. The fourth column was headed "total price," and the bidder filled in the figures "1,426,522," meaning evidently that it had in making up its gross bid, estimated $1,426,522 for this part of the work, and had figured on 16,247,400 pounds. In these circumstances, if after the contract should be let, the commissioner of bridges should decide to require high carbon steel and have drawings prepared enlarging the dimensions or numbers of the parts required to be constructed of one or the other, so as to give the bridge the same strength * * * * * * * * * * * * * * * as if nickel of the dimensions and as called for by the drawings had been used—it would seem that the contractor might well claim that it was only obliged to furnish the quantity called for by the drawings, and that it would be entitled to extra compensation both for material and labor above that quantity. And it is not at all clear that such contention would not be sustained. * * * * * * * * * * * * These matters were left altogether too vague and indefinite. This was entirely unnecessary and calculated to mislead bidders and increase the cost of the work.

Being of the opinion that this paragraph of the specifications, and the omission of drawings for high carbon steel would render the proposed contract illegal, and that the illegality cannot be obviated by evidence upon the trial, we deem it our duty, in view of the public interest and urgency of the work, to place our decision on the merits as to this point, although there are other grounds upon which the temporary injunction should be sustained. The injunction must therefore be sustained; but since, as we view the case, the work must be relet, other provisions of the contract which are assailed as illegal require comment to the end that they may be so altered that they can be sustained if again attacked.

The learned counsel for the plaintiff contends that clause HH of the proposed contract is illegal in that it authorizes changes in the character of the work and in the material which may increase the cost, and then unlawfully delegates to the engineer the exclusive right to determine the additional amount that shall be paid by the city, and also authorizes the substitution of other and different material and other changes in the work without any limitation upon the amount thereof and provides for a supplemental contract or contracts to cover the price of the same. The defendants claim that the engineer is a mere arbitrator as to whether the changes increase or diminish the cost of the work to the contractor and how much, and that this provision is analogous to those commonly inserted in such contracts and often sustained by the courts to the effect that an engineer or architect shall determine whether the work has been performed according to the contract, and certify to the fact as a condition precedent to the right of recovery on the contract. There is more difficulty, however, with the latter part of the clause. It will be seen by the other provisions of the contract quoted that mistakes and omissions, changes and alterations by mutual consent, and extra work and the compensation therefor had been carefully provided for. Counsel for plaintiff rightly contends that the provision for new contracts in the clause HH must have been intended to provide for something not otherwise covered by the contract. It apparently was designed thereby to reserve general authority on the part of the commissioner to change the materials and work, and there is a provision in the fore part of the clause, in effect requiring the contractor to make any changes he may be called upon to make as if expressly required by the contract. The learned counsel for the city concedes that this was intended to authorize any change in the contract that might be required in consequence of any unforeseen difficulty, as by the giving way of the supports for the superstructure, or any substitution of material; and also any substitution that might be deemed advisable as the result of the development of scientific knowledge with reference to the construction of work of this character at any time before the material is needed. It appears to be conceded that contract work of this nature involving an expenditure of over $1,000 is required to be let to the lowest bidder by the provisions of section 419 of the charter already quoted. We do not understand it to be contended by counsel for the defendants that there is any statutory or other authority authorizing a new contract, involving a greater expenditure than $1,000, without inviting public proposals or a three-fourths vote of the board of estimate and apportionment dispensing therewith. If any substantial change, involving an increase of more that $1,000 in the cost should become necessary or be deemed advisable, it is not within the power of the commissioner to negotiate a private agreement therefor with the contractor, but it would become necessary to invite public proposals therefor, unless this should be dispensed with as already stated.

This provision of clause HH is therefore both indefinite and misleading. No idea is given bidders of even the nature of the circumstances which may be assigned as the reason for making a material change in the contract, and they are given to understand that if there be any change in the material a new contract will be made *with them*. Attention is not called to the fact that such contract cannot be made with them as matter of right if it will involve the expendtiure of more than $1,000. If the city wishes to reserve the right to cancel the contract in the event that any unforeseen accident will prevent the performance thereof as contemplated, that should be done by a plain and concise clause. It is claimed that without clause HH the city would guarantee the sufficiency of the plans and specifications and become liable to the contractor in the event that they should prove insufficient or that the foundation should not sustain the superstructure. There appears to be no good reason why the contractor should take the risk of these contingencies, and requiring him to do so doubtless very materially increases the cost of the work. Provision might well be made limiting the recovery of the contractor in that event to a *quantum meruit*. Proposals for public work should be invited with reference to the use of *specified material* in the construction of the work contemplated. Competition is not fostered by a clause reserving the right *to change the material and work* without any limitation. It is possible to put a construction on clause HH which will make it legal; and doubtless that would be done if the contract had been let; but that would have confined its operations to changes and alterations involving an expenditure of less than $1,000, or if more than that amount, to instances in which the board of estimate and apportionment by the vote required by the charter dispensed with the necessity of inviting public proposals. Only five proposals were received, and the difference between the lowest and the highest is more than $2,000,000. These facts are quite significant, and the cause may be found in these and other indefinite provisions of the specifications and contract which would naturally, we think, deter bidders and prevent that competition which the statute, as construed by the courts, was designed to require. * * *

O'Brien, P.J.; Patterson and Clarke, JJ., concurred; Ingraham, J., dissented.

SUGGESTIONS FOR PROTECTING THE PURITY OF PUBLIC WATER SUPPLIES IN INDIANA.

A few American States are protecting the purity of their public water supplies. In geographical order, and with no attempt to indicate relative efficiency, they are as follows: Vermont, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, North Carolina, Ohio, Illinois and Minnesota. By protective work we mean something more than legislation against pollution or than chance analyses. In some of the states named little has yet been done beyond analytic work to determine whether the waters are pure or polluted, and that has not been extensive in all cases.

In our issue of Jan. 25, 1906, the State Water Survey of Illinois was briefly described and on p. 110 of our issue of the same date a proposal for somewhat similar work in Michigan was outlined. Below we give some suggestions for water protective measures in Indiana, as submitted by Mr. Chas. Brossman, Jr.,* at the close of a paper on "Water Supply as a Municipal Problem," read before the Indiana Engineering Society, on Jan. 20, 1906:

To assist in decreasing the pollution of our streams it would be necessary to start a systematic investigation throughout the State. I would suggest the following:

(1) The passage of proper pollution laws covering municipal and industrial waste.

(2) Appoint health boards or health officers in all towns not having the same.

(3) Pursue a systematic investigation of the waters of the State and their sources of pollution, by the appointment of assistants, under the direction of the State Board of Health, having tests made at regular intervals, as outlined above.

(4) Empower the State Board of Health to take up the investigation of trade wastes disposal, when such wastes endanger the public health.

(5) Have the State Board of Health approve all plans for water supply and sewage disposal and any industrial plants in which the waste is to be discharged into streams used as water supply.

(6) Give the State Board of Health the means of pursuing such investigations as have just been outlined, and an engineer as a consulting member.

The sentiment of the Indiana Engineering Society on this subject is well known. I would suggest that the society publicly voice its opinion on the passage of adequate laws relating to stream pollution and public water supply, with a view to the passage of such laws by the State of Indiana.

PRACTICAL NOTES ON CONCRETE BUILDING CONSTRUCTION.†

By C. A. P. Turner,‡ M. Am. Soc. C. E.

The members of this association may congratulate the manufacturers of American Portland cement on the uniformity and reliability of their product. They have reached this degree of perfection in their cement only by careful study of methods and materials used, combined with systematic tests of the resulting product. The cement user may well profit by their example and study their methods in the use of cement if he is to produce results at all in keeping with the high grade and possibilities of the material he is using.

In foundation work, Portland cement concrete is largely replacing footing stones, giving a continuous monolithic construction which, where the ground is soft, may be readily and cheaply reinforced with rods; and where the conditions are still more unfavorable and piling is used, a reinforced concrete cap has evident advantages over timber. In the placing of the material, it may not be amiss to suggest to those who expect results without attention and care on their part, that failure to properly mix the materials, or depositing the concrete haphazard without consolidating it by tamping and puddling, or allowing mud and sand to flow around the concrete as it is deposited, will quite likely result in a footing of little more value than one the writer was forced to remove from under a reinforced column carrying five stories. The contractor, who appeared careless to a reckless extent and thoroughly incompetent, rather than dishonest, stoutly asserted that the mixture was according to specifications and the pier according to plans. When clamps were put on the column and the footing removed, bad cement was the excuse. The idea that bad workmanship and the lack of cement had anything to do with it seems not to have occurred to him, although in removing the

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†Abstract of a paper read at the annual meeting of the National Association of Cement Users, at Milwaukee, Wis., Jan. 10-12, 1906.

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material a pick could be driven into it half the length of the blade and streaks of sand and clay unmixed with cement could be found in nearly every sample.

In exterior walls of concrete many depend for finish on a plaster coat after the work had hardened. Wetting the walls thoroughly sometimes enables a sound coat to be applied, though often there is scaling and chipping when the work dries too rapidly. Removal of the forms early, rubbing down all inequalities before the work has hardened and as soon as it has sufficiently set to stand without forms, will obviate this difficulty.

As a cheaper form of construction cement brick and concrete blocks are coming into use. The general prejudice against this type of construction amongst architects can readily be accounted for. Too many block manufacturers believe in mixing their concrete 1 cement to 7 or 8 gravel and selling it for a 1 to 3 mixture. Then, again, through the unfortunate fad of imitating rock-faced stone, our concrete block friends must be credited with the production of the most monotonous building material ever placed on the market. Too little attention seems to be given to artistic effects that should readily be obtained in the manufacture of blocks at a comparatively insignificant increase in cost. The practice of facing with a selected material such as fine white sand or crushed marble or granite with a rich mixture of cement seems to have been adopted only to a very limited extent, while as a matter of fact, it is practical and comparatively inexpensive. By casting the faces downward, the facing may be made thin and quite dry and the backing wet enough so that it will supply the necessary moisture to properly crystalize and harden the dryer facing. The object of making the facing dry is, of course, so that it can be removed from the mold without sticking to it and destroying the finished surface, which would be the result of using a wet or moist mixture. A "dry" mixture is one that is not sufficiently wet (or moist) to stick to the plates of the machine when tamped.

The writer's observation of the manufacture of cement brick is that by the use of a ¼-in. dry facing of 1 cement and 2 fine white sand, backed by a mixture of 1 cement to 4 coarse sharp sand made wet enough to stick together when a sample is placed between the thumb and finger, very satisfactory results were obtained and with no trouble in curing. On the other hand, such a mixture would force the workmen to wipe the division plates of the machine every second or third batch, and they were too much inclined to save themselves this trouble, by using a dryer mixture which could be cured, if at all, only with difficulty and repeated wetting. The difference in the amount of moisture in the two cases is slight, but the difference in the product at the end of 12 hours is very marked. At the end of that period, the brick made with a moist backing would set so that the corner would have an edge sharp enough to cut the skin of the finger if rubbed along it and if the brick were thrown against a hard block it would break in fragments like a burned brick. On the other hand, in one made with the dry backing, the corner could be readily sanded out and if the brick were treated as the other, there would be nothing but sand left of it. It may be imagined by some that there would be a plane of cleavage between the rich facing and the leaner backing, but in no case has the writer been able to break the facing away from the backing.

The cement brick the writer has had experience with, unless of considerable age, do not stand shipment well. Better methods of curing will undoubtedly remedy this and seem equally applicable to the block business. A warm, damp atmosphere is most conducive to the hardening of concrete and it would seem that a curing chamber in which the blocks and bricks could be placed and subjected to an atmosphere of exhaust steam, would be an ideal arrangement. To properly realize the possibilities in this line of work, evidently requires honest and thorough work combined with a careful study of methods and results, and when this is fully realized by those engaged in this line we may expect the architect will be ready to favor material demonstrated to be strictly high grade. This demonstration, however, must come from the manufacturer, as he cannot consistently expect the architect to specify something which might be satisfactory if the work was well executed, with the chances against this being realized.

In interior construction the advantage of concrete properly reinforced, over timber or steel, lies in its permanence, the perfect protection of the steel against corrosion or destruction by fire, and the avoidance of complicated shop details and the opportunity for the annoying little errors and endless delays incident to structural iron work.

In treating the subject from the popular standpoint, the writer would say a few words as to the reliability of the construction as compared with steel or timber. Ignorant abuse will render dangerous the best material the engineer uses; for example, some months ago the writer was called upon to inspect some coupler pockets forged out of 1¼-in. by 4-in. bars. They were worthless, the writer was told, and going to the pile and selecting four, they were placed on the ground and struck a few sharp blows with the sledge. A single blow fractured 10 sq. ins. of metal in two cases. In normal condition this area would carry 600,000 lbs. in tension. Taking the shank to a steam hammer, the center was bent flat on itself without fracture, proving that the smith had burned the steel in forging until it was worthless at the bend.

Similar inexcusable ignorance in working concrete will likewise result in inferior work, but by no means to such an extent as that instance in the case of the steel.

While the use of reinforced concrete is older than steel construction, it is only the low price of Portland cement that has brought it rapidly to the front. During the time that cement was expensive, it was naturally used sparingly and this has had an unfortunate influence in the introduction of reinforced concrete. The use of too weak a mixture and the consequent failure to secure the requisite adhesion of the steel to develop the limited strength of this concrete has led to the introduction of a number of deformed bars, the advocate of each claiming special merits. The writer has secured greater strength (as far as he is aware) in actual construction with special arrangements of plain bars, than anything claimed by the advocates of special bars, and he is inclined to regard the advantages claimed for them as a somewhat imaginary quantity. In designing the reinforcement of beams and slabs, advantage should be taken of the principles of continuity, since with constant section we have to provide only for two-thirds of the moment of a simple beam and we have but one-fifth of the deflection. Further, by properly lapping the rods we may double the section over the support and require theoretically but half the metal necessary for a simple beam the same strength. This system of design calls for the major section of metal for the flange reinforcement over the support and furnishes ample provision for shear.

In constructing work in this line it is well to bear in mind that centering is a considerable item and that each additional beam is an extra expense. This fact led the writer to use larger and larger slabs and finally to advocate construction of floors with column spacing 16 to 18 ft. c. to c., with no beams whatever, but simply a plain slab and columns. In this connection a few remarks regarding the theory of reinforced concrete may not be amiss. The theory based upon the elastic properties of the dual materials has been derived from experiments on beams and slabs reinforced in one direction and agrees fairly well with the results of tests of work involving the conditions considered in this theory. The conditions resulting from reinforcement in a number of directions are, however, not properly considered in any work with which the writer is familiar. Mr. Chas. F. Marsh makes the following statement in his work on reinforced concrete (Part 5):

Unfortunately it cannot be said that we have a thorough knowledge of the properties of reinforced concrete. It may be that we are wrong from the commencement in attempting to treat it after the manner of structural iron work and that although the proper allowances for the elastic properties of the dual material is an advancement on the empirical formulae at first employed and used by many constructors at the present time, yet we may be entirely wrong in our method of treatment. The molecular theory, that is the prevention of molecular deformation by supplying resistances of the reverse kind to the stresses on small particles, may prove to be the true method of treatment for a composite material like concrete metal. This theory is the basis of the Cottancin construction which certainly produces good results and very light structures, and Considere's latest researches on hooped concrete are somewhat on these lines.

As the writer has been able to place a test load on slabs equal to 2 or 2½ times their figured ultimate strength by the formulae presented in Mr. Marsh's treatise, without injuring the construction or apparently developing more than a third its ultimate strength, he is inclined to agree with Mr. Marsh and is in the habit of designing these slabs and guaranteeing them, not on the basis of text-book theory, but by the known relation of the new slab to the slabs tested as regards the depths and the moment of the superimposed load.

As regards the materials for our aggregate, as a matter of economy we use either crushed stone and sand or sand and screened gravel or where the natural gravel is suitable, the gravel without screening. In crushed stone, the harder the stone, the stronger our concrete. For reinforced work we use a mixture of about equal parts of sand and crushed stone ranging in size from a pea to ⅝-in. or ¾-in. diameter and about 1¼ to 1½ barrels of cement per cu. yd. of concrete. For columns we find it cheaper to secure the compressive strength by the use of a rich mixture with from 2 to 2½ barrels per cu. yd. We can depend on such concrete showing a crushing strength in cubes upwards of 6,000 lbs. per sq. in. and can readily keep the size of our columns to reasonable dimensions with ample strength. The system of reinforcement that we use, consists of a fair percentage of vertical reinforcement used for columns, with riveted hoops at intervals of the length. Where we do not employ beams, we bend the vertical reinforcement outward, making an enlarged cantilever top to the column, which is buried in the slab and supports the slab reinforcement, and we reinforce the slab in four directions. Where we employ beams, we prefer to break the floor up into panels which are rectangular and (if convenient) approximately square, and reinforce our slabs in two or more directions. If we are using gravel for the aggregate, we sample carefully and vary the amount of cement, depending upon the character of the material. If the gravel contains some clay and considerable finer material, we use a larger percentage of cement, endeavoring to get practically the same results regardless of the composition of the aggregate. Many have the idea that crushed stone has some peculiar advantage over shingle or the rounded stones that we find in our gravel. The results of a series of quite comprehensive tests made at Duluth by the Great Northern Power Co. were kindly furnished the writer by Mr. D. A. Reed, their Assistant Chief Engineer. The mixture was practically a 1-3-5. The aggregate was (1) crushed shale rock, (2) crushed Duluth granite, and (3) lake gravel. My recollection is that the crushed granite, which is practically a hard trap rock, only showed a little over 90% of the crushing strength of the gravel concrete, and that all the results seemed very satisfactory, running from 3,200 to over 4,000 lbs. per sq. in.

In mixing the material for reinforced work enough water should be used to give the mixture the consistency of brick mortar and cause it to flow slowly to fill the molds. No tamping should be required, but even with this mixture a certain amount of puddling and jarring or shaking the reinforced rods, is desirable if the best results are to be secured. Where practicable, as much as possible of the work should be run in at the same time, since a beam or a slab which is spliced will show much less stiffness than one which is cast at one time, a condition which can be readily accounted for by the shrinkage strains in the concrete.

A question which is quite frequently raised, and concerning which many architects seem to be worried, is whether reinforced concrete work can be successfully executed in winter. When engaging in this line of business this question gave the writer some little concern. His previous experience in building bridge piers when the temperature was at times 25° or 30° below zero, caused him to consider it practicable to execute reinforced concrete work in winter; we are now carrying it on every day just as we would in summer, except for the slight inconvenience that we have to keep the snow and ice out of our forms until we can fill them with concrete and are obliged to heat the material that we use. When this is properly done, freezing does not appear to damage the work as much as too rapid drying in the hot summer months.

We have put up all kinds of structures: office buildings, machine shops, warehouses and paper mills, and the writer has recently designed reinforced concrete floors for a large power station in which there are to be three of the largest vertical generators that have been built, having a capacity of 7,500 KW. with 25% overload. These are to run at the rate of about 380 revolutions a minute and are to be supported on a reinforced concrete slab of about 21 ft. span.

AN EXPERIMENT TO DETERMINE "N" IN KUTTER'S FORMULA.

By Cyrus C. Babb.*

In connection with the work of the Reclamation Service of the St. Mary project in Montana, experiments have been made on an existing canal in that vicinity to determine the value of the coefficient "n" in Kutter's formula. In the computation of canal capacities in this project "n" has been assumed as .025.

In 1902 a canal was completed in Canadian territory heading from St. Mary River, about seven miles north of the International line near Kimball, Alberta, now known as the canal of the Alberta Railway & Irrigation Co. This canal is constructed in material similar to that along the line of the proposed St. Mary canal in the United States, and it is believed that results regarding conditions of flow in the former will be applicable for computations on the latter.

Under the direction of the writer, as engineer in charge of the Milk River Project, measurements were made in the Canadian canal on July 22, 1905, by L. R. Stockman, assistant engineer, and A. M. Crain, engineering aid.

A straight stretch of canal about three miles below the head was carefully cross-sectioned and current meter measurements of discharge taken at a highway bridge (see "F" Fig. 1). A similar discharge measurement was made about one mile farther up the canal at a measuring weir as a check on the discharge. Check levels were run at the lower section, and the elevations of the

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water surface every 100 ft. were obtained for a distance of 1,000 ft., 500 ft. above and 500 ft. below the gaging section.

CURRENT METER MEASUREMENTS.—In these observations the mean velocity was obtained by holding the current meter at 0.6 depth, with a number of vertical velocity curves to check the method. The velocities were measured at points horizontally 1 ft. apart in shallow water, and 2 ft. apart in the deeper portions and were made with considerable care. The depths were measured to the nearest half tenth. The gaging showed a

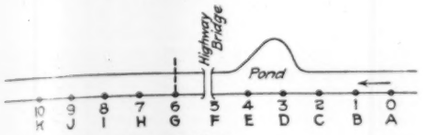

Fig. 1, Plan.

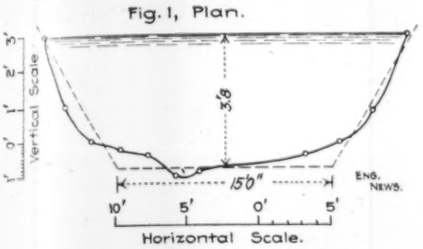

Fig. 2, Cross Section "G".

Figs. 1 and 2. Plan and Cross-Section "G" of Irrigation Canal at Gaging Station.

discharge of 311 sec. ft., and a mean velocity of 3.86 ft. per sec.

For use in the computations, a cross-section was taken 100 ft. below the gaging section, or at "G."

LEVELS AND SLOPES.—A base line 1,000 ft. in length was laid out so as to extend 500 ft. above and 500 ft. below the gaging section, along the water's edge. Stakes were carefully driven so as to set flush with the water's surface, at each 100-ft. point. Check levels were then run over the line, using short sights and reading the elevations to the nearest 1-1,000 ft.

LOCAL CONDITIONS.—The discharge measurement was taken from a wagon bridge. The section at this point was characteristic of the canal along the base, with the exception of the existence of two framed bents supporting the bridge, in the center. About 500 ft. up stream from the bridge, a pond was formed by a coulee passing across the line, at nearly right angles. (See Fig. 1). The pond extended about 100 ft. along the canal and about 50 ft. out at the widest point. This pond seemed to exert considerable local influence on the slope, probably due to sudden enlargement in the cross-section of the canal followed by a corresponding contraction.

The canal at this point is in cut, and the material is characteristic of Northern Montana and Southern Alberta. It is a glacial drift, with small rocks quite uniformly distributed and large boulders occurring frequently. There seems to be enough clay in the loam portion of the soil to cause the banks of the canal to be quite slippery when saturated with water. Where the velocity is high the rocks are found to be in prominence and the loam and silt carried away.

The canal was in fairly good order, being free from weeds and the banks well preserved.

COMPUTATIONS.—The computation of the discharge, based upon the mean velocity observed by the 0.6 depth method, is shown by the accompanying vertical velocity curves to be very nearly correct, as the percentage of the variation of the mean velocity, as taken from the curves, from the velocity observed at 0.6 depth is not more than 5% in either direction, and an average variation in one direction is not more than 2%. Hence the value of the mean velocity for the section may be known within narrow limits.

The first two curves in Fig. 3 were taken at the measuring weir, one mile above the section. Elevations were also run there to determine the slope, but the results were vitiated by obstructing brush against a barbed wire fence crossing the canal 50 ft. below the weir, and the proper grade of the canal could not be determined. The vertical velocity curves, however, give close results to those of the lower station.

The value of "R," mean hydraulic radius, was determined from the cross-section shown in Fig. 2. The dotted line in this section shows the original shape of the canal when first constructed.

The slope was obtained from various combinations of the differences of elevation shown in the following table:

Station.	Diff. ele.	Slope.
AB	—.034	.00034
BC	—.058	.00058
CD	—.013	.00013
DE	+.020	.00020
EF	—.128	.00128
FG	—.129	.00129
GH	—.125	.00125
HI	—.004	.00040
IJ	—.001	.00001
JK	—.067	.00067

The values of "V", "R" and "S" being known, the value of "N" in Kutter's formula can be readily obtained by solving the following:

$$V = C\sqrt{RS},$$

$$\text{where } C = \frac{41.6 + \frac{.00281}{S} + \frac{1.811}{N}}{1 + (41.6 + \frac{.00281}{S})\frac{N}{\sqrt{R}}}$$

The results of these computations for various combinations of slopes are shown in the following table:

Number computation.	Section used for slope.	Hyd. radius.	Velocity.	Slope.	"N" Coefficient.
1	F-H	2.81	3.86	.001270	.027
2	E-I	2.81	3.86	.000965	.024
3	E-J	2.81	3.86	.000954	.023
4	E-K	2.81	3.86	.000906	.023
5	A-K	2.81	3.86	.000929	.021
Average.					.0236

A TEST AS TO THE COMPARATIVE EFFICACY OF UPWARD AND DOWNWARD VENTILATION SYSTEMS IN THE NEW RIKSDAG'S BUILDING, STOCKHOLM, SWEDEN.*

By Wilhelm Dahlgren.†

The object of the following paper is to contribute to the solution of a ventilating question which has been and is the subject of much debate. This question is: In a meeting room with fixed seats—such as the auditoriums of theaters, concert-rooms, debating-rooms, and the like—is it best to introduce fresh air near the floor and carry off the vitiated air near or at the ceiling, or vice versa?

A new Riksdag's (Parliament) Building has just been built in Stockholm, which has been in use for one winter —and one summer—session. The above-named question had already been broached when the ventilating system for this house was planned, some ten years ago, but was then one of greater uncertainty than it is now. The resolution was, therefore, to employ a double system, i. e., to make it possible for the fresh air to pass from below upwards, or from above downwards. Both systems were to receive equal justice, and were to be treated with equal care, and experience was to decide which of the two systems was the more satisfactory.

Both Chambers have perfectly similar debating-rooms, with but that difference which is necessitated by the fact that the members of the First Chamber number 150, and those of the Second Chamber 230. The areas of the two floors, then, are in proportion to these figures, as the debating-rooms are constructed for a corresponding number of seats. The rooms are octagonal in shape, with the highest part circular in form, and have, on six sides, galleries for the accommodation of the public. The seats for the members of the Riksdag are placed in pairs with aisles on each side. The floors slope from the sides of the floor down towards the tables provided for the speaker and the clerks. The rooms are lighted from the roof. The space between the inner and the outer glass roof is warmed, so that no cold can strike downwards from the roof. The debating-rooms are surrounded on six sides by warm rooms or other premises. The two remaining outer walls are hollow-built and are warmed by means of circulating air (quite shut out from communication with the debating-room). The debating-rooms thus have no transmission of heat in any direction that could cause drafts in consequence of cold currents of air.

UPWARD VENTILATION.—The fresh, and, usually, warmed air, is driven upwards by a propulsion fan, from the lowest duct to a hot-air chamber lying above it. Above the hot-air chamber lies a regulating-room where everything concerning the ventilation of the debating-room is controlled. Here the valves in four cylindrical air shafts proceeding from the hot-air chambers are so adjusted that the air enters the air-distributing chamber at the temperature and to the amount desired. This chamber lies immediately beneath the debating-room, and is of the same surface area as the area of the floor above. For each pair of chairs there is an air-flue in the floor.

The flue is provided at the bottom with a valve which can be regulated or entirely closed, and in this way the ventilation can, to a certain degree, be regulated so as to suit the individual demands of each member of the House. In order that the air shall stream into the room at the least possible speed, cast-iron gratings with exteriorly widening orifices are employed. Experiments have shown that the air streams out almost exactly equal over the whole surface of the grating, and that the jets of air from the individual openings unite again fairly well. Were the movement of the air quite homogeneous, the maximum speed at full ventilation would amount to but 0.25 meter = 10 ins. per second. It is a specially favorable circumstance that, as we have already mentioned, the Members of the Riksdag sit in couples. This makes it possible to direct the stream of air to both sides outwards into the aisles between the rows of chairs. The air-current that actually exists, although it is but a very weak one, is, therefore, not directed forwards against the legs of those seated in the room, as is usually the case. As the gratings do not lie in the same plane as the floor, but are almost vertical and elevated above it, this does away with the usual objection, that the current of air blows the dust about. The arrangement of the gratings has, most certainly, a great deal to do with the good results that have been obtained. The vitiated air is led off by way of the ceiling. The speed, both of the electric exhaust fan and of the propulsion fan, can be controlled from the regulating room. By means of a pneumometer, an instrument for measuring small differences of pressure, constructed by G. A. Schultze, of Berlin, it can be observed in the regulating-room if there is more or less pressure in the debating-room than in the surrounding rooms, passages, etc. This exceedingly sensitive apparatus shows a difference of pressure measurable by 1-40 mm. (.001 in.) of water column. With the assistance of this valuable instrument, it is easy to control the work of the two fans in respect to each other so that a very slight degree of higher pressure prevails in the debating-room than in the surrounding rooms. This is of especial importance as preventing drafts from the doors.

To the galleries air is led from below, although in a simpler manner than that adopted on the floor of the room.

The measuring instruments employed and observed in the regulating room are, in addition to the pneumometer already named, a static anemometer (air meter) in each of the four cylindrical main shafts and pneumatic long-distance thermometers that give the temperature in the debating-room and in the galleries, etc. The anemometers are made in the form of sensitive balances, one

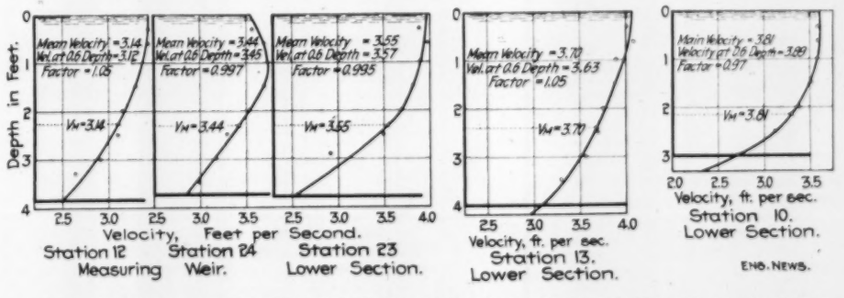

FIG. 3. VERTICAL VELOCITY CURVES IN IRRIGATION CANAL NEAR KIMBALL, ALBERTA.

*Abstracts from a paper, entitled "Arrangements for the Ventilation of the Debating Rooms of the New Riksdag's Building in Stockholm, and the Results Obtained in this respect," read before the 12th annual meeting of the American Society of Heating and Ventilating Engineers, at New York City.

†Heating and Ventilating Engineer, Stromsborg, Stockholm, Sweden.

scale of which hangs in the air-current and brings about a greater or less movement of the balance.

DOWNWARD VENTILATION.—The fresh air enters, as in the former case, by means of the propulsion fan from the lowest duct, but it is afterwards carried vertically upwards into a walled hot-air chamber beneath the roof. Its steam valve is controlled from the regulating room, but there are in addition two large mixing valves for cold and warm air, which valves are also controlled from the regulating room. The air, which is adjusted precisely by these valves, both as regards quantity and temperature, now enters the circular duct, before mentioned, that communicates with the debating-room by means of the narrow opening around the ceiling of the room. The outlet expands inwards towards the room in order that the speed of the air shall be reduced on its streaming in. The vitiated air is now taken through the same gratings beneath the seats which previously formed the inlets, and thence comes into the chamber beneath the room. From this chamber a vertical shaft leads up to the same exhaust fan that served for carrying off the vitiated air in the former case. From the different rows of the galleries the vitiated air is also carried off through the same openings that formerly allowed the fresh air to stream in, and the vitiated air is carried downwards to the same shaft that serves for the ground floor of the debating-room. In this system, too, special distance thermometers and anemometers and pneumometers are also employed, so that both systems are equally complete in every respect.

When the debating-rooms were first occupied, the air in the one room was allowed to go upward, and in the other room downward, while nobody was informed that any difference in systems existed, or of the direction in which the air went. In the debating-room where, for the occasion, downward ventilation was being employed, a general uneasiness and complaints arose in consequence of the drafts. But when upward ventilation was employed, nothing was heard any more. This experience was gained both in the First and Second Chambers, although it was at different times that downward ventilation was employed in the one or the other room and without any one being informed of the matter. The result was that in both debating-rooms all attempts to use downward ventilation were abandoned, so that at present nothing but upward ventilation is employed.

THE WORK OF SUPERPOSING THREE LINES OF THE METROPOLITAN RAILWAY OF PARIS, AT THE PLACE DE L'OPERA.

By R. Bonnin.*

Three lines of the Metropolitan Railway system of Paris cross at the Place de l'Opéra; these lines are: the one from the Boulevard de Courcelles to Ménilmontant, now in operation; that from the Palais Royal to the Place du Danube, now under construction; that from Auteuil to the Opera, still under study. The first of these lines passes above the other two.

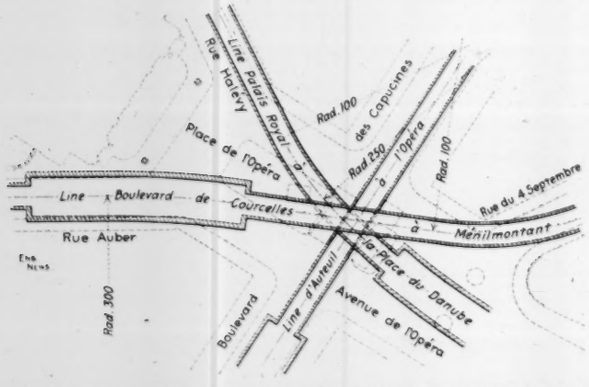

FIG. 1. PLAN OF CROSSING OF THREE LINES OF THE METROPOLITAN RY., AT THE PLACE DE L'OPERA, PARIS, FRANCE.

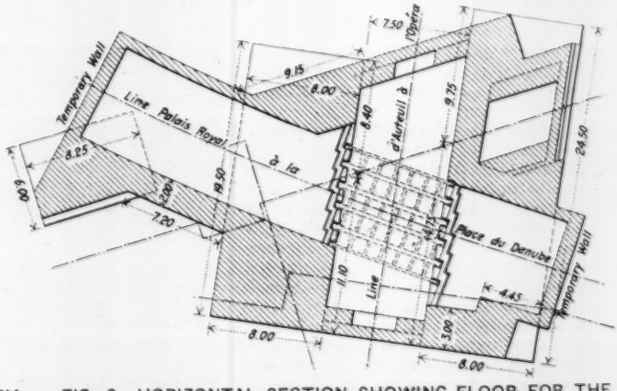

FIG. 2. HORIZONTAL SECTION SHOWING FLOOR FOR THE LINE, PALAIS ROYALE A LA PLACE DU DANUBE.

The work of superposition of these three lines includes, at the base, three masses of masonry, A, B, C, Fig. 1, founded by means of compressed air. Their dimensions are, respectively: 8.25 m. in length by 6 m. in width; 19.50 m. in length by 8 m. in width; 24.50 m. in length by 8 m. in width. The first was set at the point where the left skewback of the arch of the line from the Boulevard de Courcelles to Ménilmontant begins to be superposed above the works of the line from the Palais Royal to the Place du Danube. The directions of the second and third are parallel, and are marked by the axis of the line from Auteuil to the Opera; they are separated by a space of 7.50 m. The masonry masses reach down, to all intents and purposes, to elevation 15 of the general levels of France;* they were dressed off on top at reference 24.10, corresponding to the water-bearing stratum. Masonry piers, built on these masses where the three superposed lines cross, form the abutments for the arches which support the gable walls built at the head of each of the underground entrances to the three lines (Figs. 2, 3 and 4).

The masonry carries three metallic floors: the first under the roadway of the Place de l'Opera; the second under the rails of the Boulevard de Courcelles-Ménilmontant line; the third under the rails of the line from the Palais Royal to the Place du Danube.

The floor under rails (Fig. 3) which carries the line from the Boulevard de Courcelles to Ménilmontant has four twin beams supporting the rails of the track. The spans of these beams are, respectively, 20 m., 17.50 m., 15 m. and 12.50 m. Side beams carry the sidewalks. The floor beams, 2.30 m. c. to c., are assembled on the beams, the space between them being filled by brick arches covered with concrete, on which are laid the tracks.

The floor under the roadway of the Place de l'Opera (Fig. 4) is divided into two parts; one triangular, the other trapezoidal in shape. The triangular part has two main beams, with spans respectively of 12 and 14 meters, with a height of 2.70 m. The trapezoidal part has also two main beams 2.70 m. high, one being 14 m. long, the other, having a total length of 23.50 m., is divided by an intermediate support into two firmly connected beams of 13.50 and 10 meters respectively. Each of the parts of the floor is made up of cross beams, to which are fastened stringers forming a support for the brick arches overlaid with concrete and carrying the public highway.

A small work-yard at the Place de l'Opera, where one of the caissons for the support of the structure of the three superposed lines was to be sunk, was occupied on March 24, 1903, and it was only on April 6 of the same year that the whole of the space required was fenced in.

As the Prefecture of Police denied access to this yard for the dump carts for removing the excavated materials and for bringing in the material required for the work, this service had to be insured by means of underground galleries. These galleries, which were first revetted with timber and gradually, afterwards, with masonry, followed line No. 3 of the Metropolitan through the Rue Auber, Boulevard Haussmann and Rue de Rome, to the station at the Place de l'Europe, from which a side track led to the lines of the Western Railway (chemins de fer de l'Ouest). It was over this side track that several trains of platform cars, loaded with the excavated material dumped on them from the gallery cars, were run out every night when traffic on the main lines had subsided somewhat. The gallery cars were handled by compressed air locomotives, each capable of hauling on a level 12 cars, holding 4 cu. m. each. This method, devised by Mr. Chagnaud, the contractor for the work, rendered excellent service in the matter of quickness in handling material, while still satisfying the condition that earth should be kept away from the work-yard at the Place de l'Opera.

The progress of the work, according to the successive periods of the yard, may be stated briefly as follows:

Work was begun by digging a first trench whose bottom was levelled off at reference 32 which corresponds sensibly with the floor of the underground galleries used for removing the excavated materials.

The erection of the first caisson was begun at this level on April 21, 1903; the caisson is 8.25 m. long by 6 m. wide. The sinking of this caisson was begun on May 9; it was carried on, without the use of compressed air, to reference 24.10 where, on May 25, the first water-bearing stratum was met. From this point, the use of compressed air was necessary, and with it the level of the foundation of the work (15.61) was obtained. This caisson was sunk at the rate of 34 cen. (13.4 ins.) a day, in spite of certain difficulties and stops due to the presence of large blocks of grit.

The second caisson, 19.50 m. long by 8 m. wide, was built between May 5 and 21. After its base had reached reference 27.34, its sinking had to be stopped for the convenience of the yard. It was begun again on July 31, and was stopped on August 31, when the level of the foundation (15.51) had been reached. The average progress from July 31 to August 31 was 38 cen. (15 ins.) a day.

The third caisson, 24.50 m. long by 8 m. wide, was much the largest, and, at the same time, it was the nearest to the buildings on the east side of the Place de l'Opera. The construction of this caisson lasted from May 16 to June 14. Sinking was begun on June 19; the water-bearing stratum was reached on July 4, and after that the operations were carried on by means of compressed air to reference 15.93, which was reached by the base of the cutting edge on July 29. The sinking went on at the rate of 37 cen. (14.6 ins.) a day.

The foundation masses being thus finished, the construction of the piers and walls was started, with arches corresponding to the different lines, which are built above the masses and serve to support either the floors, on which are laid the rails for the line from the Boulevard de Courcelles to Ménilmontant, or the floor carrying the street.

The first of these floors was set up between October 23 and November 4, 1903. The floor of the roadway was built after the preceding, and, although the work was much impeded by bad weather (rains and snow), the revetting was finished on Dec. 10, and the construction of the arches on Dec. 17, the concrete work on Dec. 19, and, after relaying the public highway, the islands of refuge could be given over to pedestrians on Dec. 24, and on the morning of Dec. 27

*61 Rue Louis Blanc, Paris, France.

*The zero of these levels is mean low water on the tide gage in the Mediterranean near Marseilles; the references are all in meters.

all obstacles to the circulation of vehicles had disappeared.

The entire work of the superposition of the three lines was thus done during the period between March 24 and Dec. 27, 1903.

Like all the other work of the Paris Metropolitan, that of the superposition at the Place de l'Opera was carried on under the direction of Mr. Bienvenu, Chief Engineer, and Messrs. Biette and Locherer, Associate Chief Engineers.

SEDIMENTATION: ITS RELATION TO DRAINAGE.*

By J. W. Dappert.†

Sedimentation is that process by which fine particles of soil, sand, vegetable matter or other detritus, being carried along or held in suspension by water or other fluid, settle down to the bottom of the channel or vessel when the moving fluid acquires slow velocity or comes to rest. Siltage, although a term synonomous with sedimentation, applies more to the product of sedimentation, after the process has taken place, or in other words is a measure of sedimentation. Both these terms have a broad application in the economics of nature, as well as in modern processes of art; they apply to the precipitation formed by chemical action in the test-tube of the laboratory, on the one hand, and upon the other, to the action of a mountain torrent, cutting away the banks of a canyon and carrying debris and even rock fragments weighing many tons. It is a process by which a very large proportion of the most fertile lands of the earth have been formed.

SEDIMENTATION IN DRAINAGE WORK.—Turning to the subject of sedimentation in its practical relation to drainage, we observe that as soon as a channel or ditch is completed an accumulation of sediment begins (slowly or quickly) to fill it up again. There being little literature upon this subject, I am compelled to draw upon my own experiences, and the conditions favoring siltage upon the great rivers are all reproduced in miniature upon the drainage ditch.

The Coon Run Drainage District, located upon the line between Scott and Morgan counties, has its outlet into the Illinois River, a short way below Meredosia. The upper part of the district has rapid slopes, and several small streams throw their waters down upon the central part, which is quite level, having formerly been a marsh comprising nearly 1,000 acres. The ditch, after leaving the marsh, makes a deep cut through a sand ridge, thence goes west a mile or so to the Illinois River. It was completed in 1901, but has become filled up almost to the original surface, the embankments of earth thrown out upon each side serving alone to restrain the water, and they are often out through during floods.

I made a study of this ditch in 1904, taking a number of measurements in June of that year and again in May, 1905, and it is the worst case of silting up of a ditch which has come under my observation. The channel has filled until the bed of the ditch in many places is not more than 6 ins. deeper than the natural surface of the land outside the levee. This ditch was constructed, as I was informed, nowhere less than 5 ft. deep, and was more than 18 ft. deep where it crosses the sand ridge, and the volume of earth thrown out indicates that a ditch of good size and depth had been constructed. If the cut was as deep as presumed, the ditch has become filled from 4½ to 6 ft. in the space of four years. Work was suspended for nearly a year at the point where it crosses the Wabash Railway pending some litigation relative to crossing the track with a dredge, and as the construction was proceeding down stream this hindrance was favorable to a deposition of sediment. The small creeks entering the marsh from the high lands carry large quantities of sediment during floods, much of which is a heavy fine sand, and this has lodged in the ditch, filling it up almost completely in its flatter portions, within the marsh, so that there is practically no drainage of the marsh.

It is probable that any open ditch constructed in like manner, and under the same conditions, will fill up similarly; yet here is a very fertile tract of land, badly in need of drainage, and the question is by what method can it be secured. The volume of water going down during flood is too great to admit of the use of tiles or pipe, although the area of flat lands, if segregated from the high lands, could all be well provided for by underdrains. If the open ditch could be carried on a more even gradient, by making a circuitous route, getting rid of the steep gradient at the upper end and securing more fall in the lower portion, there would be much less difficulty in the matter of siltage. Such a ditch might be called a diversion ditch, and might be constructed of greater width and less depth, making it less expensive to construct in the first place and more easily cleaned out when required. The earth taken from such ditch might all be placed on the lower side, to help impound the waters during floods, and a storage reservoir might assist in impounding the waters coming from the high rolling lands. Such a ditch would be without water a great portion of each year, so that it could be readily cleaned out at intervals. The system of tile drains to perform the real drainage of the marsh area is a problem in itself which does not seem formidable.

Many of the drains throughout the central Mississippi valley are similar to the one just described, and require the solution of like problems of siltage. Throughout the entire Sny Island Levee and Drainage District, along the Mississippi River, the creeks coming from the higher lands with steep gradient carry down sediment, shingle, and even rocks weighing tons. There seems to be no practical method of preventing the erosion, or none that would come within reasonable bounds of cost. The fertile lands subject to over-wash and inundation from the creeks are as rich in productive capacity as any in the world, and if overflow from the smaller creeks could be prevented or checked in a large degree these lands would become very valuable. They are at present protected from overflow by the levee next the bank of the great river, and this part of the system is fairly effective, but the trouble comes from the overflow of the creeks entering the low bottoms behind the levee. This levee, following its meandering course, is about 140 miles long, and has not a single opening in its entire length for the outflow of the waters; and there are seven large creeks entering the bottoms from the higher lands, mostly having very steep gradients. The entire drainage of the district is designed to be cared for by the "Sny" ditch, having, where largest, a 50-ft. base and averaging about 3 ft. in depth, paralleling the river and from two to three miles distant therefrom. The large number of lagoons and lakes throughout the district serve to aid the ditch by impounding the waters during floods.

This ditch has been cleaned out and enlarged from time to time, and to keep it in fair condition has required the services of a dredge-boat somewhere along the line almost constantly. Very large quantities of sediment are brought down by all the creeks, and I have seen a deposit of from 6 to 12 ins. thick covering many acres as a result of a single overflow of a creek. This, when occurring during the crop-growing season, is very destructive to farming operations, although enriching the land. The method of prevention of siltage of the ditches in this district still remains an unsolved problem.

In the Inlet Swamp Drainage District near Amboy, Ill., quite an extensive system of open ditches has been constructed, the work extending over a period of 20 years or more, at an expense of $250,000.* At the outer margin of the swamp area the lands rise rapidly, the drainage area of approximately 80,000 acres of high lands throwing down its surplus water upon an area of original swamp and flat lands, comprising about 30,000 acres. A main drain, with a large amount of rock excavation work, was cut below the swamp proper, and because of the rock work being quite expensive the ditch was constructed to a width of 20 ft. with vertical sides through this section, but having almost double the gradient of that section immediately above. The portion of the main ditch above the rock cut widened at once and was made with a cross sectional area of nearly three times that through the rock-cut, but was not so deep, its gradient being considerably less, but it had a much greater carrying capacity. Going further up stream, various branches joined the main stream; these were designed with narrow base, flatter side slopes, and as constructed were very nearly proportioned so as to convey a sufficient quantity of water to merely fill the main outlet ditch upon the section above the rock-cut. The laterals all increased in gradient as they approached the rim of the basin, or swamp, where they joined with and formed outlets for the small creeks coming from the higher lands, and in these upper sections the ditches as constructed were from 4 to 6 ft. deep, had from 3 to 5 ft. base widths and side slopes 1½ horizontal to 1 vertical.

If these ditches could have been maintained as constructed, a fairly good system of drainage would have resulted, and temporarily the drainage of the swamp was an accomplished fact. Most of the land immediately came under cultivation, produced large crops for a few years, and real estate values jumped up to a good figure. But from the time of the construction of these drains the agency of their destruction began work: erosion in the steeper portions and sedimentation in the flatter sections.

I noted while examining these drains during August, 1905, that near their heads, where the open drains had been made with a base-width of 3 or 4 ft. and a depth of 4 or 5 ft. near where they join upon and form outlets for the natural streams, these ditches are now more than 100 ft. wide in many places and 300 ft. wide in one place, and of about the same depth as originally constructed. A large proportion of the materials excavated by erosion has found lodgment within the lower and flatter sections of the ditch, and has very greatly reduced the carrying capacity of that portion of the system, until now the ratio of capacity of the main ditch compared with that of the laterals is about 1 to 10, with inundation of the low swamp lands and destruction of growing crops thereon, as a logical result. If, when the first signs of great erosion became evident, a system of drops, revetment works and dams had been employed in the sections of ditches having great fall, training works placed along the small

*Abstract of a paper presented at the annual meeting of the Illinois Society of Engineers and Surveyors, Rockford, Ill., Jan. 17, 19, 1906.

†Civil and Drainage Engineer, Taylorville, Ill.

*This was described in Engineering News, Jan.-June, 1905.

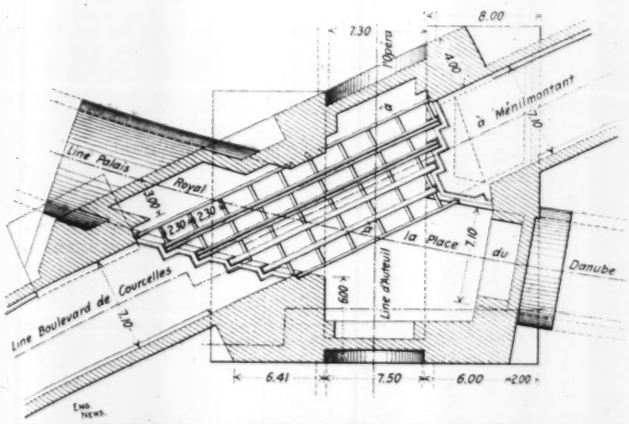

FIG. 3. HORIZONTAL SECTION SHOWING FLOOR FOR LINE BOULEVARD DE COURCELLES A MENILMONTANT.

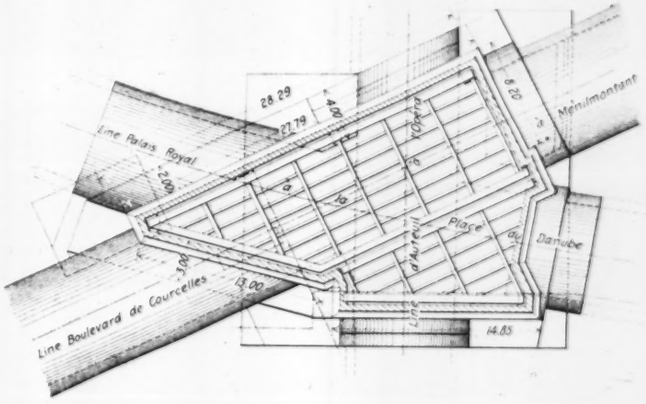

FIG. 4. HORIZONTAL SECTION SHOWING FLOOR UNDER ROADWAY OF THE PLACE DE L'OPERA.

creeks higher up, with drops and dams, thereby retarding the flood-flow, and holding back the storm waters, to prevent largely the erosion and consequent siltage, then the first proportion of capacity between the main ditch and its laterals could more nearly have been maintained, and the comparatively small outlet ditch would have sufficed to convey the waters of ordinary floods without damage; and the whole system of drainage would still be as effective as it was soon after its construction.

It might seem that a study of different cross-sectional forms, gradients, etc., as applied to different kinds of soils, would throw much light upon the question how to avoid siltage. The literature as applied to drainage upon this subject is very scant. Much has, however, been written upon this same subject as applied to irrigation ditches, and in so far as conditions are similar this sort of literature is valuable.

In Water Supply Paper No. 87 of the U. S. Geological Survey, by Herbert M. Wilson, much is said about "scouring velocities," different velocities being required in the different kinds of soil. He shows that to prevent siltage a mean velocity of flow of from 2 to 3 ft. per sec. is required, the higher velocity being required in a sandy soil. Considerable stress is also laid upon the matter of too great velocities, tending to undermine the slopes of the ditches and consequent caving off of the banks. I find among authorities upon drainage in our own country a table showing "scouring velocities" about as follows:

	Ft. per second.
Very fine clay	0.40
Very fine sand	0.70
Light vegetable soils	0.83
Sand as coarse as flax seed	0.91
Gravel, size of a pea	1.40
Small pebbles	2.52
Pebbles 1 in. in diameter	3.00
Pebbles size of hen's eggs	4.15
To wear away shale rock	6.40
Stones 1 ft. in diameter, etc.	9.90

Knowing what velocity is required to scour just sufficiently to prevent the deposition of silt, the matter of devising a cross-section suitable for the available gradient ought not to be a difficult task. But there is no fixed rule which will determine the siltage which may occur in an open ditch. You cannot forecast with precision what rate of silting will occur within a given time, and I find by experience that all ordinary ditches constructed in earth will either erode and undermine the slopes, thus preparing material which will "silt up" some other portion of the ditch, or otherwise "silt up" directly by the wash brought in from the adjacent lands.

Two contiguous drainage district ditches of which I was the engineer in charge were constructed at the same time; character of soil similar, drainage areas practically of same size, both from 6 to 9 ft. deep. District A had its main ditch with a base width of 5 ft., gradient 5.2 ft. per mile, and was constructed with a dry-land dredge working up stream. District B had its main ditch with a base width of 2½ ft., gradient 1.7 ft. per mile, and was constructed with teams and scrapers working up stream. The side slopes were 1½ horizontal to 1 vertical upon both ditches. Both were completed during 1899 and the work was well and properly done, good clean channels being left upon completion. I have recently made the following observations: The dredged ditch, District A, has sloughed off the slope, undermined somewhat, especially at the curves; sediment has accumulated in the bed from 1½ to 2 ft. in depth, and many flags grow within it; the banks have become steep and sometimes concaved; the present base width is from 10 to 14 ft., as measured at the top of the silt accumulation. Upon the whole it does now or will soon require very extensive repairs. The team-and-scraper ditch, District B, where the conditions were more favorable to silting by reason of the lower gradient, does not differ materially in its present condition from the ditch just described. The slopes have also sloughed off and undermined, have formed almost vertical sides, sometimes concaved; sediment has accumulated from 2 to 2½ ft. in depth; many flags are growing within the channel, and the present base width is from 10 to 12 ft. It will also soon require very extensive repairs.

What surprises me is that there is such a great similarity of physical conditions of these two ditches, when one has three times the fall of the other. They have both filled up very rapidly the first year of their existence, and less rapidly later. As their drainage areas are but 4,000 acres each, I have recommended (and we will most likely do the work this year) that large tiles be laid within the bed of these ditches. When the tiles are once laid such repairs of the open ditch as are required can be readily made at almost any season of the year. If the drainage areas were so large or other conditions unfavorable to the employment of tiles, these open ditches would require being reconstructed with a dredge. I have recently reconstructed two ditches with dredges, and am not wholly pleased with the results. In the one instance I could not get sufficient top width, owing to the proximity of a wagon road, whose utility would be destroyed if encroached upon further, and as I could not have my own way in the matter of laying a large tile, instead of deepening the old ditch, we were compelled to cut a deep ditch with almost vertical slopes, and much sloughing off and some caving of the banks has already developed within six months after its completion.

From my experience and connection with more than a hundred drainage districts, I have formed the following conclusions in relation to siltage:

All open ditches tend to fill up from the day they are dug, either by sloughing or deposition of suspended sediment. The nearer the cross section and gradient of artificial channels conform to that of the natural streams in their locality the better they will maintain themselves. If you must build an open ditch, build it amply wide and amply deep to admit of such sloughing of the slopes and much silting which are sure to follow. Build it deep enough to admit the outfall of the tile-drains several feet above the bed of the open ditch, if possible. Make the curves "easy" or long, base wide, and get the waste-banks well back from the margin of the ditch. Build concrete or other good substantial retaining walls at all the tile-outlets upon the ditch. Admit surface waters of the smaller drains by means of pipes, whose outlet ends are well down toward the bed of the open ditch, and provide concrete retaining walls upon these if the land owners (who pay the bills) do not tighten their purse strings too quickly. Have the ditches patrolled regularly after floods to locate and correct any little evils which will result in great injury if left unattended, such as drifts, improperly constructed flood-gates, bridge piers within the channel, and many like matters. Go over the lines of ditches and pull out all the small willows, cotton woods and other trees, and if any parent trees line the banks, or are located so closely as to furnish seed for the propagation of these undesirable kinds of timber, kill them also.

With all these things done and even well done, the open ditches will yet require frequent recleaning, but their period of efficiency can be greatly extended by their proper care and management. Lastly, I reiterate, do not build an open ditch where a tile-drain, pipe or conduit can possibly be employed.

A VARIABLE-SPEED WATER POWER PLANT WITH CONSTANT-CURRENT ELECTRIC TRANSMISSION AT VARIABLE VOLTAGE AND FREQUENCY.

A unique pumping plant for an irrigation system at Keila, in the island of Kauai of the Hawaiian group, is being supplied to the Makee Sugar Co. (Mr. Z. S. Spalding, President) by the Allis-Chalmers Co., of Milwaukee, Wis. Some information about the arrangement of the plant has been furnished us by the makers, and is summarized in the following. As will be observed, the machinery of the plant is remarkably interesting, but unfortunately no details are given, so that the operation of the plant can be only partially understood.

The remarkable features of the plant are: (1) the use of variable-speed water wheels, and (2) electric transmission at *variable voltage* and *variable frequency*, with constant current. The plant is designed to utilize fully, at all times, the available water power, by adjusting the load to suit, and yet preserving high efficiency of operation. The arrangement used accomplishes this control of the load wholly from the generating station, without relays or other remote-controlled mechanism, but solely by the variation of line voltage and frequency. The total power of the plant is small, only 300 KW., and the distance of transmission is only five miles.

The problem to be solved in this irrigation project was to utilize as fully as possible a small but variable flow of water, under a high constant head, for pumping irrigating water from an abundant underground supply at a distance from the source of power. The heads at both power and pump ends being constant, the amount of pumpage should vary in direct ratio to the flow of power water. With a reciprocating pump, as was here adopted (presumably for best efficiency), the pumpage varies with the speed, and the requirement therefore was to vary the speed of the motor in direct proportion to its load, without material reduction of efficiency of the motor. At the power-generating end, on the other hand, the governing requirement was that the peripheral speed of the water-wheel should remain constant, since with constant spouting velocity, due to a water-supply of constant head, the efficient peripheral speed of the wheel is fixed. The electric generator would then have to be of such nature as to deliver variable power, in proportion to available supply, with unchanged peripheral speed of water-wheel.

This latter part of the problem was solved by providing a water-wheel of special design, having six rings of buckets on different diameters, so that with constant bucket-speed six different speeds of revolution are obtained. The generator, coupled directly with the water wheel, has an output varying directly with the speed. It is a Bullock alternating-current generator supplied with a constant magnetizing current from a separate exciter. The voltage produced by the generator, and its frequency, will therefore vary directly with the speed of revolution. The current generated and sent out over the transmission line is substantially constant.

The generator is rated at 300 KW., and produces three-phase current whose frequency is 60 cycles per second at the (normal) speed of 450 r. p. m. As already noted, it runs at widely different speeds, depending on the available water supply, and its voltage and frequency increase or decrease as the speed increases or decreases. The exciter is an 8-KW. direct-current dynamo, mounted on the generator shaft and therefore subject to the same variations in speed as the generator. An automatic regulator serves to maintain the voltage of the exciter constant at all speeds, so that the generator fields will be excited to constant strength. A manual field regulator, for emergency use only, is also installed.

The receiving end of the plant, five miles from the power station, comprises only one unit, a three-phase induction motor rope-belted to a Riedler pump. The motor is rated at 225 HP. The pump works against a gross head of 250 ft. and gives a maximum delivery of 2,800 gals. per min.; its speed at this output is 116 r. p. m. The pump is fitted with mechanically-operated valves, and is by-passed for starting.

The makers state that the pump will discharge 1,750 gals. per min. against 250 ft. gross head when the water wheel receives 5 cu. ft. per sec. at 400 ft. head. The total efficiency of the plant, on this basis, is 48% from water to water.

A synchronous instead of an induction motor was at first proposed to drive the pump, but this would have required a 50-HP. motor for starting, and also an exciter, controllers and apparatus for throwing the motors in and out, in place of controlling apparatus, merely. The induction motor will be as efficient as a synchronous motor, simpler and cheaper in construction, and more reliable in operation, besides requiring less attention day by day.

A CONTRACT BETWEEN A LABOR ORGANIZATION and a corporation was recently upheld in the Lackawanna County Court at Scranton, Pa. In the suit of Thomas Neary, a motorman, against the Scranton Railway Co., to recover two weeks' wages withheld by this company, it was brought out that, at the close of a strike about three years ago a contract had been made between the Street Railway Men's Union and this company. One of the provisions of this agreement was that if the company desired to discharge an employee, who was a member of the Union, it must give him two weeks' notice, and if discharged without this notice, he was entitled to two weeks' pay, and vice-versa. The plaintiff quit without working out his two weeks' notice and the company withheld two weeks' pay from the amount due him. The agreement was produced in court, and after Neary admitted that he was a member of the Union, Judge Newcomb gave binding instructions to the jury to render a verdict for the company.

FIVE-CENT LOCAL TELEPHONE RATES for calls at pay stations have been announced for the New York and Brooklyn exchanges as soon as improvements in plant can be effected, or, say, by July 1, 1906. This reduction was announced on Jan. 19 by Mr. Union N. Bethell, General Manager and Vice-President of the New York Telephone Co., and President of nine companies whose territory centers in New York and stretches from Syracuse to Washington, D. C. The 5-ct. rate was made effective by Mr. Bethell in Washington and Baltimore three years ago; in Philadelphia two years ago, and in the New York suburban district during the past year. Thirteen years ago, when Mr. Bethell took charge of the telephone system in New York, there were less than 10,000 telephones in Manhattan and the Bronx, against over 175,000 at present. In the whole territory served by the companies with which Mr. Bethell is connected there are now about 600,000 telephones, or more than in Great Britain and France together.

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Entered at the New York Post-Office as Second-Class Matter.

According to newspaper reports, the Pennsylvania R. R. Co. is seriously considering the driving of a very long tunnel beneath the summit of the Allegheny Mountains to lower the grades on its main line. Two routes are said to be under survey, one employing a 9-mile tunnel and the other a 11-mile tunnel. The eastern portal would be somewhere in the vicinity of Kittaning Point, at the famous Horseshoe Curve, and trains would emerge at the west between Cresson and Lilly. The present summit of grade on the Pennsylvania main line is at the Gallitzin tunnel, about 2,160 ft. above sea level, and the line from this point to Altoona drops a vertical distance of nearly 1,000 ft. in 12 miles. How much elevation could be saved by a long tunnel we are not informed; but such data as we have at hand indicate a probable saving of 500 to 600 ft.

It is almost needless to say that the traffic through any such long tunnel would, of course, be moved by electricity; in fact, it is doubtless the recent advances in the design of heavy electric locomotives that have given an impetus to such tunnel projects.

It may be added that while the tunnel, if built, would rival the famous Simplon tunnel in length, it could be constructed in far less time than the Simplon tunnel, as the height of the mountain above is not too great to prevent the driving of intermediate shafts.

The Pittsburg dispatch referring to the above project states that the tunnel, if built, would be a four-track line. This seems to us exceedingly improbable. A two-track tunnel, with electric motive power and with short automatic block sections throughout its length, could handle an enormous amount of traffic, particularly if only one class of trains were run through it and heavy motive power were used so as to haul long trains. In all probability freight trains alone would be hauled through the tunnel, as passengers would certainly prefer the scenic attractions of the present line to the ride through a tunnel nearly ten miles long, where the air, even with electric motive power, would surely be far from agreeable.

A project on closely parallel lines to the above, which has only reached the stage of preliminary consideration, relates to the Lehigh Valley R. R. At present, as those of our readers familiar with that road are aware, a long climb is made from the headwaters of the Lehigh River until the summit is reached at a point near the brink of the steep mountain which overlooks the Wyoming Valley at an elevation of over 1,700 ft. By making a new line and driving a tunnel about seven miles in length through the narrowest part of the range, a vertical lift of several hundred feet would be saved, as compared with the present line, and a great reduction would be effected in the cost of moving the heavy coal traffic which this company handles to tidewater.

Long delays in shutting off large water mains in which serious breaks had occurred, on two different occasions within a relatively short time, seem to justify the opinion that something is wrong with either the design or operation of the water distribution system of New York city Not many years ago it was commonly known that the city was deficient in the matter of valves to control the flow of water in the street mains, and that one or at best a very few men made personal capital of the fact that the location of the controlling mains and valves was nowhere mapped except in their own heads. So dangerous a condition should not, of course, be tolerated in a small town, much less in the first city of the land, and we believe that it has been largely, if not wholly, remedied for several years. But in the light of the two recent breaks there is still room for improvement in the New York water department. The location of the break on Fifth Ave., early in the present year, was complicated by the fact that there were, at that point, six large mains, side by side, and that it was necessary to shut these off one by one before the leak was located. The incident suggests, in addition to what has already been noted, a strong objection to laying large mains side by side, particularly in an important thoroughfare. Quite aside from the confusion which resulted in the present case, and much of which was perhaps quite unnecessary, there is always a danger that a break in one main will cause a washout that will undermine and result in the failure of one or more of the others. It is only fair to say, however, that breaks have rarely extended to multiple mains; but that may be due more to luck than anything else.

Every little while some one writes to the newspapers criticizing the railway companies for building umbrella platforms instead of train sheds at their important terminals, as for example at the new railway terminal at Washington, D. C., or that of the Delaware, Lackawanna & Western R. R. at Hoboken, N. J. It is generally assumed by the writers of these letters that the change from the large structure to the small one is evidence of the railway officials' disposition to neglect the comfort and convenience of the travelling public.

The reply to such criticisms is that the railway officials have learned by experience, what the general public does not know, that the huge arched-roof train sheds, of which many notable examples were built in this country a dozen years ago, are bound to be short-lived on account of the rapid corrosion of the iron and steel by locomotive gases. They give trouble by leakage from start to finish, and only constant vigilance saves the passengers using them from frequent casualties due to falling glass. As they grow older and their weakening by corrosion proceeds farther they become more and more of a menace and their ultimate removal in a time far shorter than those who erected them ever dreamed is now tolerably certain.

In the light of present knowledge the best arrangement for the tracks at a railway terminal appears to be either umbrella platforms between the tracks; or, if a train shed of some sort is demanded, then build a structure with moderate span roofs of reinforced concrete and with no metal exposed to corrosion.

As for the frequent objection that the umbrella roofed platform gives inadequate protection to passengers in bad weather, it is not apparent why the passenger can fairly demand any different protection at a railway terminal than is given him at local stations. A roofed-over walk from the car to the waiting room really answers all reasonable requirements.

Attention is justly called to this matter of large train shed roofs in connection with the recent fall of a part of the roof of the Charing Cross station in London. This structure ranks among the great roofs of the world, covering an area 500 ft. long with a single span of 165 ft. It was built in 1860, and the roof is carried by iron trusses of crescent form resting on walls 40 ft. to 60 ft. in height. In the collapse and fall of two bays of this roof, which took place on Dec. 5 last, the immediate cause, according to reports in the English engineering journals, appears to have been an old flaw in one of the main tie bars of the roof truss, 4½ ins. in diameter. It is stated, however, that the examination which followed the accident showed that the iron-work of the trusses was very seriously corroded. One section of the main compression member of the truss, which was originally a half-inch plate, had been corroded to a thickness of less than 3-16 in.

We understand that the accident has set British railway managers and engineers at work on a general overhauling and examination of the condition of all the large train-shed roofs; and we shall be surprised if the results of the examination are by any means reassuring. It may as well be confessed that the extent to which corrosion has reduced the strength of a great complicated steel structure like a trainshed roof is not a matter which can be computed or estimated with mathematical accuracy.

While American railway engineers have hitherto been chiefly concerned regarding the maintenance of the skylights, the wire netting guards and similar minor details, in the train sheds here, the time is not far distant when the effect of corrosion on some of the main members may need careful consideration. It is true that most large American trainshed roofs are of recent construction compared with those in Europe; but on the other hand most of them are built of steel instead of iron, and it is likely that some at least have been under worse conditions of attack by smoke and acid gases than the English train sheds.

Ten years ago Dr. W. W. Jacques, of Boston, came before the public with a claim that he had invented a new process for the production of electricity by the direct combustion of coal with an efficiency of over 80%. The alleged invention was thoroughly discussed in our issues of May 21, 1896, and Sept. 29, 1898, and the conclusion reached was that Dr. Jacques had wholly failed to prove his claims.

A correspondent in Boston sends us now a copy of a prospectus of the Direct Electric Co., in which Dr. Jacques again describes his process and asks subscriptions to the stock of a to-be-organized company, the proceeds to be devoted to the work of developing the process, which is admitted to be not yet at the stage of commercial success.

This proposition is fair enough and a perfectly legitimate use of investors' money, provided the statements made in the prospectus are not of such a nature as to deceive the investor with false hopes. On this point, however, it is our duty to say that the present prospectus appears to be as deserving of criticism as were Dr. Jacques' publications of ten years ago. He repeats his old claim in the following words:

> In numerous laboratory tests—made with apparatus of scientific value but not adapted to extended commercial use—there has been obtained as electricity *by far the greater portion of the energy contained in the coal consumed.*

If this were true, Dr. Jacques might very reasonably appeal to investors for financial support; but the fact is that Dr. Jacques' claims were thoroughly and publicly discussed a decade ago before scientific societies and in the technical press and were definitely rejected. If his patent then issued had really been based on sound principles and had really shown the way to the production of electricity by the direct combustion of carbon, the experiment would long ago have been repeated in a hundred laboratories and would have been established as a scientific fact whether it had been commercially successful or not. Dr. Jacques has had ten years

in which to prove before reputable scientific experts that his alleged laboratory test on which he based all his claims was genuine. His failure to secure the verification of a single expert in all this time, and his present appeal for money without such verification raises the strongest presumption against his good faith.

The extent and earnestness of the labor union crusade against the use of concrete in building construction is illustrated by the fact that the subject, like Banquo's ghost, will not down even at a banquet. At least we find the following in the Minneapolis "Journal" for Jan. 12, 1906:

> Concrete construction came in for strong denunciation at the banquet of the bricklayers' and masons' convention last evening. The delegates view with alarm the steady increase in the use of concrete, which can be handled by unskilled labor and will, it is feared, seriously reduce the demand for skilled bricklayers and masons.

A further instance of the way the trade unions are bidding fair to hurt themselves by attempting to dictate what materials shall be used and how work shall be divided, or lumped, for contract letting is afforded by another paragraph in the report of the same meeting, as follows:

> The New York delegation came before the convention with the demand that the constitution be changed so that it would no longer be possible for builders to let separate contracts for brick-laying and fireproofing. Two years ago the union made this concession at the instance of some of the fireproofing firms and now feels that it got the worst of the deal.

We have already commented (Jan. 11, 1906) on the attempt of the bricklayers of Newark, N. J., to monopolize the placing of concrete in that city, and on the order of the unions in some of the adjacent municipalities that concrete for buildings must be dumped on a mortar board and after that put between the forms by a mason, with a trowel.

Unless we mistake the temper of the American public it will never allow a cheap and efficient building material, in every way suited to its purpose, and of great economic advantage to all classes of people, to be sacrificed to what is at best the temporary interest of a very small number of artisans. Concrete is bound to be used in increasing quantities and the broad claims of industrial, economic and social progress demand that it be made and placed in the cheapest manner consistent with strength and utility. It is one thing to fight for reasonable hours and a fair wage for the particular class of labor suited to mixing and placing concrete, and quite another to insist that skilled workmen and corresponding wages be substituted, with absolutely no benefit to anyone except the new set of men.

A COURT DECISION THAT SPECIFICATIONS ON PUBLIC CONTRACTS MUST ACCURATELY DEFINE THE WORK.

The decision on appeal in the case of the Manhattan Bridge contract is a valuable contribution to the law of public works contracts. The engineering profession has special cause to welcome it, because it brings into clear relief some simple basal principles of specifications and lettings for public works which are often lost from view for their very simplicity. Fundamentally, under American laws, the public must be protected against unfairness in the expenditure of its moneys by competitive bidding whenever public work is done by contract. Local ordinances are left to govern the details of procedure of the bidding. Where the ordinances are not sufficiently specific the courts will so interpret them as to secure real competition. Justice Laughlin says:

> Plans and specifications of sufficient definiteness to require competition on every material item are required, and must state the quantity of work required as definitely as practicable.

This principle, which the present opinion premises as an axiom of public contract law, was applied with remarkable, almost startling, looseness in another recent case in New York City, where a large public contract was involved. It is reassuring to find that in the present case a narrower, safer construction of the rule is employed.

In discussing that clause of the Manhattan Bridge contract form which provides for future changes in work and materials, as might be required by "the conditions at any time prevailing," Justice Laughlin rebukes the practice, which, unfortunately, has been steadily increasing among engineers, of providing for extra or changed work by very sweeping and arbitrary clauses in the specification. Of Clause HH (quoted in our issue of Nov. 30, 1905, p. 580) he says:

> This provision * * is both indefinite and misleading. No idea is given bidders of even the nature of the circumstances which may be assigned as the reason for making a material change in the contract, and they are given to understand that if there be any change in the material a new contract will be made with *them*. * * Proposals for public work should be invited with reference to the use of *specified material* in the construction of the work contemplated. Competition is not fostered by a clause reserving the right *to change the material and work* without any limitation.

Here is a concrete warning that if the drafter of a contract for public work is not careful to specify the required work clearly, and make his provision for changes limited and definite, he runs the risk of having the contract declared void. There is generally not the slightest excuse for clauses which reserve to the engineer (or public department) the right to order any and all changes, namely, "such changes in plan or materials as he may at any time deem necessary." As a matter of observation, such clauses are usually chargeable either to excessive caution on the part of the engineer or to insufficient care in designing the work and preparing the specifications. As regards motive, these clauses are precisely analogous to the ubiquitous phrase in architects' specifications: "The contractor will also provide and place all other materials that the architect may direct as necessary to make the building complete as contemplated." Only, this last-named clause infests private contracts almost enclusively, and therefore, while it is inimical to fair competition, it does not come to the notice of courts of law.

It is a notorious fact that public contracts are to a large extent made up of extras. The contractor who can put in the largest bills for extras is admired as ingenious and successful. Justice Laughlin's decision should aid in bettering these conditions. Extras are often necessary: the conditions of contract work are never fully known until the work is completed. But the unnecessary extras, those which result from the engineer's carelessness or neglect or from the insinuating arguments of the contractor will be largely guarded against by omitting the sweeping "extra and changed work" clauses and substituting a clear specification of what work *outside the contract price* may become necessary due to imperfect knowledge of conditions, and by giving the contractor security against frivolous or harassing changes in the work.

The alternative specification of two kinds of steel for the stiffening trusses of the Manhattan Bridge, a novelty in public work, is now finally declared to be illegal. It is illegal, first, because it is unnecessary and is an added hazard to the bidder; therefore makes the work more costly to the city; and, second, because it opens a way for collusion, which would give one bidder an advantage in enabling him to base his bid on the cheaper material. We have previously quoted paragraph 254 of the specifications, in which this alternative specification is made, but it will bear repetition:

> 254. In the suspended superstructure, the main parts of the chords and of the diagonal web members of the trusses, the gusset-plates connecting the diagonal web members of the chords and the chord splices shall be made of nickel steel, or of high-carbon steel of the quality hereinbefore specified. All the rest of the material shall be made of medium carbon steel, except as otherwise indicated in the specifications or on the plans.

The decision against this clause appears to be based on the fact (which the evidence is held to establish) that there is a material difference in cost between the two materials. But the opinion is not quite clear on this. It may be held to contain the broader assertion that the alternative specification is illegal, irrespective of difference in cost. For the present it is safer to interpret the decision as being based on the difference in cost. On this view it would still be legal to specify alternative materials which are absolutely identical in cost, as, for instance, two steels commercially produced in the same manner but differing ten points in carbon. The identity of cost should be established beyond question, however; otherwise the court will say, as it does in this case: Do not let your contract until you know what material you require, so that you can specify just what you want and get lowest price by fair competition.

A very important point is made by the court in connection with this alternative specification: The omission of drawings or specification of quantities for the bridge as designed with high-carbon steel (in addition to those for the nickel-steel bridge) is in itself fatal to the legality of the contract. The court holds that the work required to be done should be described so clearly that no doubt can exist as to the amount of material and work covered by the contract. It is not sufficient that the successful bidder and the parties of the first part should be mutually agreed as to the meaning and scope of the contract, but every bidder must be equally able to form a correct idea of the nature and amount of work called for, otherwise fair bidding is not secured. Precision and completeness of the plans for the work is demanded by the court, just as in the case of the clause for changed work above mentioned.

THE FIRE RESISTANCE OF CONCRETE AS INFLUENCED BY COMPOSITION.

What effect has the composition of concrete on its ability to resist fire? Is a rich or a lean mixture, a fine or a coarse stone the better? Does the character of the sand or of the coarse aggregate affect the fire resistance of the final mixture? We publish elsewhere in this issue two papers which attempt, each in a different way, to answer these questions. The important thing to be noted, however, is that these papers point to the conclusion that it is no more the character of the aggregate that determines the fire resisting value of a concrete than it is the fineness of the aggregate, the richness of the mixture and the perfection of its manufacture. This opinion has not been brought forward prominently before this, and, while it cannot be regarded as being established by the papers mentioned, they suggest possibilities that are certainly worth serious consideration.

In fireproofing practice it has come to be assumed that certain materials used as aggregate produce concrete which is highly resistant against damage by fire, and that certain other materials produce concrete that is not so resistant or which may be dangerously weak under attack by heat. It is, for example, considered that steam cinders make a concrete of very high fire-resisting qualities, while limestone and certain crystalline rocks make a concrete that will quickly go to pieces when subjected to high temperatures. Theoretically, both of these assumptions have reason behind them; tests, unfortunately, are rare, and the few which have been made do not give concordant results. A brief review brings out this fact clearly.

In the tests made by Prof. Ira H. Woolson, of Columbia University (Engineering News, July 13, 1905) to determine the effect of heat on the crushing strength and elastic properties of concrete, comparative results of identical mixtures of trap-rock and of limestone concrete were obtained. A ¾-in. stone, a 1-2-4 mixture and a 4-in. cube were used in both sets of specimens. The comparative tests of unheated cubes showed a very small—practically insignificant—superiority of strength of trap-rock over the limestone concrete. On the contrary, the comparative tests of the heated cubes indicated clearly the great superiority of strength at all temperatures of the trap-rock concrete. Briefly, the loss in strength of the limestone cubes was large at 500° F., and at 2,000° F. the specimens crumbled to shapeless masses upon cooling, while the trap-rock cubes retained their full normal strength at 500° F., and at 2,000° F., though badly cracked, sustained upward of 600 lbs. per sq. in. in all cases.

These figures, on their face at least, appear quite effectually to rank limestone materially lower than trap-rock as an aggregate for fire-resisting concrete. They stand alone, however. The tests of concrete beams by the National Fire

Protection Association's Committee on Cement for Building Construction (Engineering News, Aug. 3, 1905) included one beam having limestone aggregate, and so far as the published report of the test indicates this beam showed quite as good results as did any of the others. In reference to this the report, however, says:

> While the tests did not demonstrate it, the fact is that limestone and granite, especially in cases where the individual stone are of large size, by breaking and bursting under fire have in other tests broken the concrete mass, and these stones are, therefore, not generally considered reliable for good concrete.

The test of concrete slabs of different compositions conducted by the British Fire Prevention Committee and described in another column did not include a limestone concrete, but it did include a granite concrete slab, and this appears to have stood up quite as well as did any of the others. Referring still to this test, it will be noted that the slabs, which in the committee's opinion, made the poorest showing, were those of furnace clinker and of Thames ballast concrete.

The tests cited, and they include practically all of any value that have been made public, give us small basis upon which to pronounce judgment as to the relative value of different aggregates for producing a fire-resisting concrete. We may, however, piece out this evidence with a little theory and get at something slightly more conclusive. There is no doubt of the poor heat-resisting qualities of limestone or of granite and other coarse crystalline rocks. Theoretically, they should be poor aggregates for a concrete intended to resist fire. By the same token, cinders, being the indestructible products of intense heat, should be a very good aggregate for a fire-resisting concrete. Taking everything into consideration, it is perhaps reasonable to conclude, as does the Committee of the Cement Users Association, whose report forms one of the papers mentioned above, that trap-rock, or silicious gravel, or strictly clean furnace clinker, is a more desirable aggregate for fire-resisting concrete than most other materials. Is any of them enough more desirable to warrant us in insisting upon its use? To us it hardly seems so, and it may be worth while to cite briefly the reasons.

The Committee of the Cement Users' Association itself points out that cinders are practically unobtainable in sufficient quantities for general use in concrete work. Even were they plentiful enough for all purposes, they would be of limited utility. Cinder concrete does not possess the strength necessary for reinforced concrete work or for concrete building blocks. It may be used as veneer fireproofing, and it may be used for floor slabs of moderate span and carrying moderate loads on steel beams; but not with safety or economy for such girder and column and arch work as is now being done on every hand with reinforced stone concrete. There can be no possible doubt of this fact. In respect to trap-rock aggregate, the conditions are both similar and dissimilar. There is perhaps no better aggregate for concrete for any purpose than broken trap-rock, but it is commercially available only in certain localities. A silicious gravel is more readily procurable, but even this material is not to be had everywhere at a cost which permits of its use.

Evidently, the concrete worker, if he is to use the aggregates that are assumed above to be the best for fire-resisting concrete, must in many cases go abroad for his material. Now, as a plain matter of fact, he cannot afford to do this. He must be able to use the local stone and gravel and sand, or he is put behind in the competitive running with tile, and steel, and timber. The fundamental advantage which the builder in concrete possesses is his ability to find in almost any locality the bulky materials for his work, and to get them cheaply because they are at hand. To ask him to forego this advantage without a very compelling reason is preposterous, and we submit that no such reason is shown in what we know of the superiority of one material over another of the materials in common use as a fire-resisting aggregate for concrete.

Are our resources in producing a fire-resisting concrete limited to choosing certain aggregates of presumably high fire resistance? It hardly seems reasonable, and we would call the reader's attention to the argument of the Committee of the Cement Users' Association on this question. Portland cements, so far as our knowledge of the fire resistance of standard brands reaches, may be regarded as of uniform and equal value. Fire resistance of cement being a constant, we are restricted in variations tending to influence the fire resistance of concrete to such as result from changes in the relative proportions of the materials and the methods of combining them. Is a rich or a lean mixture, a wet or a dry mixture, the better? On these questions we quote the remarks of the Cement Users Association's Committee:

> The necessity of a dense, fairly rich concrete, practically free of voids, such as is produced by a wet mixture well tamped, is well known to all experienced users of the material, and the troubles occasioned by mixtures containing too little cement, or made too dry, or not properly tamped, are perhaps too familiar to some of us. This feature has a direct bearing on the fire resistance of the structure, as a dense, rich mixture is much less liable to spalling and disintegration than a poor, porous concrete; and if the theory is correct that the dehydration of the cement itself or the driving off of its water is what weakens the mass, then the richer in cement the mixture is, and consequently the more water is contained in the mass, the longer the cement will last, because a longer time will be required to drive off the large amount of water. Furthermore, its factor of safety above the strength required for normal conditions is naturally much greater, and that has a most important bearing on the fire-resistance feature. A structure so built that a considerable proportion of its ultimate strength may be destroyed by fire without causing a collapse obviously has a much greater chance of escaping total loss than one which, though non-inflammable, has no great strength above that required for normal conditions; and so would be subject to collapse on the failure of some one or two of its vital members.

An item not brought out clearly in the above quotation is the influence of the size of the particles of aggregate. Practice varies greatly in this matter, ¾-in., 1-in. and 1½-in. stones all being used. The report of the National Fire Protection Association's committee, quoted some space back, intimates a preference for small stones; the reasoning, though not stated, is doubtless as follows: Stone being less fire resisting than cement, the composition should be such that the cement will shield the stone; this composition is best obtained by using stone of small size. Stone is destroyed by heat by spalling or bursting, while cement is destroyed by powdering slowly and evenly from the surface inward, the powdered layer remaining in place, unless mechanically removed, and serving as an insulation to the sound material beneath. With small stone the spalling and bursting forces are correspondingly small, and the damage done by them much less than would be the case were larger stones used.

To summarize briefly, much can be gained in fire resistance by making the concrete a reasonably rich mixture of cement and small stone and taking care to secure a dense material by wet mixing and thorough compacting. We are not confined to a few chosen aggregates as our only resource for securing high fire resistance. When trap-rock and limestone are equally available, it is perhaps wiser, in the light of our present knowledge, to use trap-rock; it would hardly be wise to sacrifice cement and workmanship, however, in order to compensate for the extra cost of trap-rock when it has to be imported. It will very likely be wiser to use the limestone at hand and put a little extra money into cement and extra care in mixing and depositing.

LETTERS TO THE EDITOR

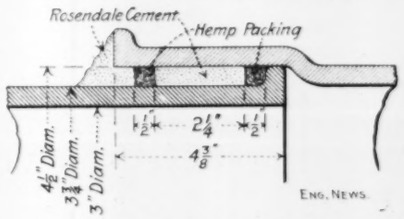
Some Old Cement Joints in a 3-in. Gas Main.

Sir: Since reading the article in Engineering News of Dec. 14, 1905, concerning cement joints for gas mains, I have run across some such joints in an old gas main, which was uncovered in excavating for foundations in a vacated street. The line was 3-in. cast iron pipe, laid about 4 ft. below the surface. The street was paved with cobblestones laid in a sub-base of gravel. It has had very heavy traffic over it for a number of years.

All joints which were examined were in perfect condition. The main was put in in 1876 and was used for artificial gas supplied to consumers until 1903, when the natural gas superceded it and the line became dead.

The arrangement of hemp packing and cement in the joints is shown by the accompanying sketch, from which it will be seen that the packing and cement alternate, there being two rings of each. The ring of cement between the two rings of packing ranged from 2 to 2½ ins.

One thing was very noticeable and that was the perfect preservation of the hemp packing and the pipe.



An Old Cement Joint in a Gas Main.

There was not the slightest sign of corrosion. The cement was intact around the socket, even after the pipe was broken near the joint with a sledge.

Yours truly,

C. P. Clark,

241 Miller St., Knoxville, Pittsburg Pa., Jan. 18, 1906.

Does the Use of Heated Mixing Water Injure Cement Mortar or Concrete?

Sir: I would like to be informed as to what effect the mixing of Portland cement mortar with hot water would have on the cement. At this season of the year precautions have to be taken to prevent the mortar from freezing, and the custom is quite common of heating the sand and stone. Generally it would be more convenient to heat the water. I have been told, however, that this is bad practice, as the hot water "kills" the cement. If this is true, why does not the heating of gravel and sand in mixing concrete affect the cement also?

Yours truly,

"Subscriber."

Rochester, N. Y., Jan. 21, 1906.

(So far as we know, there is no warrant for believing that water at any temperature to which it is likely to be heated in actual construction work does the slightest injury to a sound cement. Mr. L. H. Sabin, in "Cement and Concrete," gives the results of tension tests of cement mortar briquettes molded with all materials at a temperature of 110° F., and states that "the conclusion indicated is that the ingredients may be used cold or warm indifferently." It is well established, if not common, practice to heat all the ingredients of concrete except the cement in concrete construction in freezing weather. A notable example may be cited from our correspondent's own city, where, in constructing the reinforced concrete factory buildings of the Foster-Armstrong Piano Co., Rochester, N. Y., the broken stone, sand and mixing water were all heated by the apparatus described in Engineering News of Sept. 7, 1905.—Ed.)

The Responsibility of the Panama Engineers to Their Profession.

Sir: I desire to express my hearty approval of your proposition in your editorial of Jan. 18, that the engineering profession is responsible for the work at Panama and that both those in charge of the work and the profession generally should try to live up to that responsibility. Everyone of us knows from private conversation that the public generally is watching the progress of the work there with keen interest, and that any blunders by the engineering force and any failure to live up to a high professional and moral standard are sure to be charged in the public mind to the discredit of the engineering profession.

For a generation, nearly, there have been repeated efforts to have the Government place its River and Harbor engineering work in the hands of civilian engineers; but the Panama Canal is the first case where this long advocated policy has actually been given a trial by the country, and where well paid civilian engineers have been given full responsibility for the conduct of a great engineering work. Certainly the events in connection with the reorganization of the Commission and the changes in its executive force and the circumstances that made it necessary were matters for profound regret to every member of the profession, since they tended indubitably to discredit it in the public mind.

Now, however, things on the Isthmus seem to be proceeding in satisfactory shape, and it is equally the duty of those on the work to do their level best and of their professional brethren at home to use their influence for fair treatment by the public. The capital of an engineer and of the engineering profession is measured not in

dollars and cents but in honorable reputation. Let us be very careful to preserve it unimpaired.

"Esprit de Corps."

St. Louis, Jan. 21, 1906.

(Our acknowledgments are due to several other correspondents for letters expressing appreciation and approval of the above-mentioned editorial.—Ed.)

The Trisection of Angles.

Sir: There are two methods older than Christianity for trisecting an angle. The first one, by means of the conchoid, is the one upon which Mr. Llewellyn bases the construction of his cute little instrument described in Engineering News of Jan. 4, 1906. This method was invented about 150 B. C. by Nicomedes (Alexandria?). The other is by means of the cardioid, the inventor of which I could not find in any history book. A third method, of my own invention, employs the intersection of a circle and a parabola for finding the roots of cubic and biquadratic equations. By expressing the tangent of an angle in terms of the tangent of its third part, a cubic equation is obtained, which may be solved by purely graphical procedure and the desired trisection of the angle thus drawn.

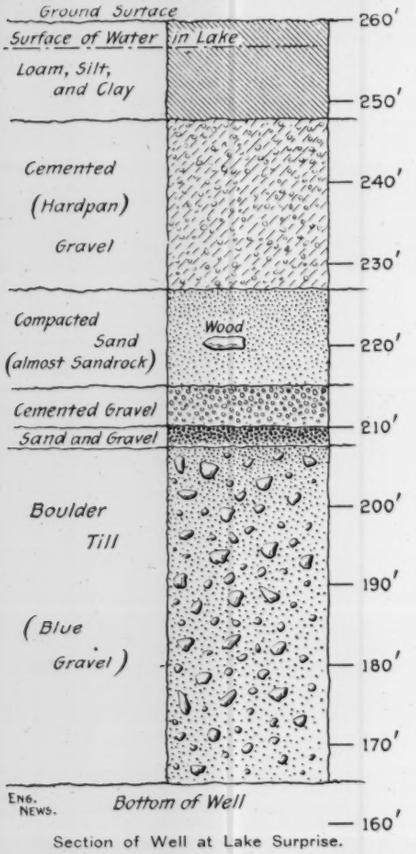
Yours,

Francis Rust, C. E.,

1341 Kentucky Ave., Allegheny, Pa., Jan. 10, 1906.

Sir: Concerning the "straight-line instrument for trisecting an angle," described in your issue of Jan. 4, in which the author "has not seen mentioned elsewhere the fact that HE = 2AB," allow me to quote from "Mathematical Recreations," by W. W. R. Ball, edition of 1896, p. 186, changing the letters to suit the figure as published:

"The following two constructions are among the oldest and best known [methods of trisecting an angle] of those which have been suggested; they are quoted by Pappus (1670), but I do not know to whom they were due originally. The first of them is as follows: Let BAJ be the given angle. From any point B on AB draw BJ perpendicular to AJ. Through B draw BH parallel to AJ. On BJ take a point E, so that if AE is produced to cut



Section of Well at Lake Surprise.

BH in H, then EH = 2 AB. If this construction is made, then JAE = ⅓ JAB," etc.

The problem which vexed the early Greek mathematicians was the trisection of any arbitrary angle by the constructions of Euclidean geometry, i. e., by the use of straight lines and circles alone. Conic sections and other curves were found to afford the necessary means, however, and "Nicomedes (150 B. C.) invented a simple device for tracing the conchoid. It is the oldest instrument of the kind beside the straight-edge and compasses."

The newly devised instrument under discussion suggests an ordinary method of drawing an ellipse, which, in fact, is the trace of the general point on the "ruling stick," and we are led to question as misleading the propriety of terming it a "straight-line instrument."

The impossibility, save by successive approximations, of trisecting an arbitrary angle by means of compasses and straight-edge alone is capable of rigid mathematical demonstration. See Beman & Smith's translation of Klein's "Vortrage über ausgewählte Fragen der Elementargeometrie," Ginn & Co., 1897. Reference is there given (p. 47) to a list of instruments of recent construction for accomplishing the result in question.

Respectfully, R. H. M.

Barge Canal Office, Fonda, N. Y., Jan. 14, 1906.

Another Ancient Piece of Buried Wood.

Sir: During the past summer a well was dug on the border of a pond called Surprise Lake, in Pierce County, about 10 miles from Tacoma and near the station Edgewood, on the Seattle-Tacoma electric railway.

In sinking the well nothing unusual was noticed or encountered until a depth of nearly 40 ft. had been reached, where imbedded in sand formation of such hardness that picking was almost impossible (and it was deemed safe to continue sinking without putting in cribbing; which decision was fully justified by the facts that the well was continued to a depth of 95 ft. without any of this material caving in, and too that the material stands today as it did the day it was excavated showing all the pick marks), in fact it was almost a sandstone—was found a "chip" of wood about 4 × 8 ins. and from 1 in. to 1½ ins. thick, as well as a shovelful or two of smaller bits.

As will be seen by the cross-section herewith, the top 12 ft. was composed of loam, silt and clay; at this depth the "cemented gravel hardpan" of this region was struck. This formation prevails throughout this Puget Sound region and is almost as hard to penetrate as a concrete made with natural cement. This hardpan continued for a depth of 22 ft., and was equally dense and hard to penetrate for the total distance. Directly beneath that the sand formation lay, which, though a little softer at the contact with the hardpan, soon became almost as difficult to work. This stratum was about 11 ft. thick and was succeeded by another layer of hardpan about 5 ft. thick. Then came a layer of sand and small gravel not 3 ft. in thickness, which was succeeded by a stratum of "boulder till" (or what is locally known as "blue gravel"), in which the well was sunk to a total depth of 95 ft., at which depth the work was stopped because no flow of water was struck.

From the United States Geological Survey's "Tacoma Quadrangle" it will be seen that Surprise Lake lies on top of a gravel plateau (which covers this whole region) at an elevation slightly more than 250 ft. above sea-level. The ground rises gently from the lake surface to the rim of the basin about 30 ft. higher and half a mile distant. There is no steep acclivity from which this bit of wood could have been carried by a "slide," and nothing in the vicinity to show any disturbance of surface conditions. That there is no connection with the lake itself is proven by the fact that the well, although only a hundred and odd feet from the lake's edge and barely 2 ft. above its surface, was sunk to 95 ft. depth without getting any seepage therefrom. Nothing in all this "gravel plateau" region indicates any faulting or upheaval such as would have buried this wood in any manner. There is no rock showing on the surface within 12 or 15 miles. And, while bed-rock has not been determined, it is known that it is below 100 ft. in the neighboring valley of the Puyallup; and below 300 ft. at Tacoma.

As yet there has not been brought together sufficient evidence to warrant the statement that all this glacial deposit was formed and deposited at once; but enough is known to say that it took place in one "Geological day."

The piece of wood found in this well was of a medium brown color, fine-grained and seemingly a "hard wood" variety. Though quite doty, it did not split when struck with the pick, but permitted the pick to pass completely through; and was so firmly embedded that it could not be pried out, but had to be completely excavated.

Everything shows that this bit of wood was found "in situ" where it had lain "since time immemorial."

Yours very truly, A. McL. Hawks.

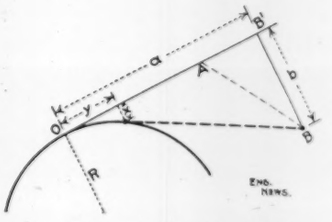
462 Berlin Bldg., Tacoma, Wash., Jan. 4, 1905.

(In our issue of Nov. 23, 1905, there appeared an account of a piece of wood found in a deep excavation in New York City.—Ed.)

Projecting a Tangent from a Curve to Pass Through a Fixed Point: Another Solution.

Sir: Mr. William N. Frickstad's solution of the more or less famous problem "To pass a tangent to a given curve from a point outside the curve," suggests another solution for the same problem. This solution might at first sight seem more difficult, although it will be found to contain many advantageous points so far as general use and the amount of field work required are concerned.

Given the radius of curvature, R, and the point through which the desired tangent is to be run. At any point on the curve, as O, run in a tangent O A, which approximately takes the direction desired. Select a point A on this line and measure the angle O A B. The length of lines O A and A B being measured, the distances O B′ and B′B may easily be found; call them a and b respectively.



Assuming a system of rectangular co-ordinates with O as origin, we may write the equation of the circular curve,

$$x^2 + y^2 - 2 \times R = 0$$

Let the co-ordinates of the required points of tangency be (X, Y); then

$$X^2 + Y^2 - 2 \times R = 0$$

The equation of a tangent line through the point B to the circle in terms of the point of contact:

$$bX + aY - R(X + b) = 0$$

$$\therefore Y = X(R - b)/a + Rb/a$$

In which Rb/a and (R—b)/a are constants, which may be called c and c′ here. Then

$$Y = cX + c'.$$

Then by eliminating Y between the given relations there results

$$X^2 (1 + c^2) + X (2cc' - 2R) + c'^2 = 0$$

$$X = -\frac{(cc' - R)}{(1 + c^2)} \pm \sqrt{\frac{(cc' - R)^2}{(1 + c^2)^2} - \frac{c'^2}{(1 + c^2)}}.$$

The terms that occur in this formula for X are symmetrical, so that the necessary computation will be reduced to a minimum in actually evaluating the expression for X. When X is known the value for Y may be quickly found, from the fact that $Y = Xc + c'$. By analyzing this problem in this way we do not bring the center of the circular curve into play at all, thus making the field work easier than it would be by using trigonometric methods.

When the approximate direction of the tangent is located it should be so taken that the point B will fall in the first quadrant of the system of co-ordinates. This leaves the values of X and Y always positive. They may easily be laid off along the tangent O B′. The point thus located will be the point of tangency. The plus or minus sign introduced in the expression for X shows that there may be two tangents from the point B.

Yours truly, G. L. Bilderbeck.

Ithaca, N. Y., Dec. 19, 1905.

(A misunderstanding seems to be implied in the above letter, where it says that the method here shown does not "bring the center of the circular curve into play at all, thus making the field work easier." The method previously shown does not require the center of curve to be accessible, since nothing more is required to be known than is required for the above solution, namely: the radius of the curve, the azimuth of some part of the line, and such alinement data as will enable the fixed external point to be referred to the center of curve in latitude and departure. The latter data may be compiled from previously existing notes, or may be determined by a traverse such as is also required in the method shown in the above letter. The comparison of the two methods must therefore base on relative ease of computation. We would suggest, further, that in problems of field location those methods are to be preferred which employ only simple geometrical or trigonometrical relations, and which are so clear and natural that, the principle alone being remembered by the field engineer, he can rapidly work out the detail procedure anew in each particular application. There will then be no need to carry around a collection of problems and their solution, as is found in the first part of most field books, but a book of tables with some general notes of methods will be sufficient for all uses. The method given in the previous letter appears to meet these requirements, while the one shown in the present letter would require to be available in printed or written memorandum.—Ed.)

Some Comments on the Austerlitz Bridge for the Paris Metropolitan Railway.

Sir: The interesting article on the new Austerlitz Bridge published in Engineering News of Dec. 7 contains statements, several of which I believe to be inaccurate, and conveys also the impression that several features, which are really old, were new developments.

The statement that arch bridges with fixed ends are heavy is generally true only for arches of a relatively small rise, that is with a rise of, say, less than one-third of the span. In case of high arches the stresses due to changes in the temperature do not reach such a figure that it is necessary to use extra material to provide for them, particularly as it is quite customary and justifiable to permit a greater allowable stress for the determination of sections if temperature stresses are considered than if they are not considered at all. Such arches have sometimes smaller weights than any other type of bridge, except, perhaps, suspension bridges. However, I do not think that would have been the case with the Austerlitz Bridge, but they have been used quite successfully in many cases, for example, at Berne (Kornhausbrücke) and at the great railroad bridge near Müngsten with 114 m. and 180 m. spans, respectively. I cannot consider it a drawback that such arches are statically indeterminate systems, for such systems offer no greater difficulty to a well trained engineer than any other system.

On the other hand, there are good reasons why the three-hinged arch is seldom used on railroad bridges, for its line of deflection has a sharp break at the center, giving rise to not infrequent breaks of rails at that point.

For example, in the lower part of Fig. 1 the line of deflection of the top chord of the three-hinged arch is shown as produced by a load of 1 metric ton applied at the center; this being the line of influence for the center point gives its total deflection under the train load shown as 142.3 ins.

Though it is certainly true that it is desirable to make the arch of a greater height if the line of thrust goes outside of the arch, this is by no means necessary. But I doubt if it is true that by reducing the length of the arch the line of thrust can be kept between narrower limits, the quotient of the live load to the dead load being far greater for smaller spans. If the ground is so unreliable that it is impossible to use a simple, two-hinged arch, I think it far better to use a two-hinged arch with tie-rod, as shown in Fig. 2, representing the railroad bridge over the Rhine at Worms, built in 1897 by Harkort. This system, offering a very handsome view and a smooth line of deflection, has the great advantage that the top and bottom chord bracings may be made continuous from one end of the bridge to the other, giving great lateral stiffness.

The author of the article on the Austerlitz Bridge puts a very strong emphasis on the arrangement of the hangers or posts, adopted there. In my opinion it is quite natural to have a fixed point only at the center and to distribute the expansion equally to both sides; certainly this is nothing new and it has been done also at the Rhine bridge just mentioned, only the cross girder at the center being fixed to the tie rod, the other ones being suspended movably. In many cases there are provided real hinges in the hangers or posts, for example, at the Schlossbrücke at Charlottenburg near Berlin and at the highway bridge over the Rhine at Worms, in order to do away entirely with the bending stresses in the hangers.

The railroad bridge at Worms has some other features worth mentioning. The tie rod is suspended independent from the floor except at the cross girder at the center, where a special bracing transmits the bracing forces to the tie rod (Fig. 2c), and the hangers and cross girders are pin-connected, which, together with a special arrangement of the lateral bracings, permits an entirely independent deflection of the main girders in case of one-sided loading of the double track bridge, without any additional stresses in the hangers, cross girders and bracings (Fig. 2 d and e).

The use of the deck floor of sheet steel plates is not new, as it has been used in this way in numerous bridges, among others at the highway bridge over the Rhine at Worms, named before, and built in 1896 by the Nürnberger-Maschinenfabrik, Brückenbauanstalt Gustafsburg.

Dowels for the transmission of the lateral forces between different parts of bridges as described in the article on the Austerlitz bridge have been used very extensively for cantilever bridges, the earliest case I know of being at the Warnow Bridge, near Rostock, 1885.

K. A. Müllenhoff.

813 Franklin Ave., Wilkinsburg, Pa., Dec. 12, 1905.

Winter Work on the Transcontinental Railway Survey.

Sir: Since starting our survey here in the territory allotted to our party, on the new Canadian Transcontinental railway line, last July, we have been successful in getting a fairly good line, and by no means a heavy one. We have about 50 miles of line to our share, about the average amount allotted to each party. In our District, F, there are eight parties in the field working under a district engineer, and covering about 400 miles of distance. As the country was new and unexplored, and no available maps of it were therefore procurable, our first work was to run an exploration line as the basis for making a good map of the country. We took no contours on this line, but the topographers were not limited to any distance from the line on either side. Sometimes they would have to follow out a range of hills, a stream or lake for a mile on either side of the line. Hills were put on the map by hatchings, and the courses and directions of rivers and lakes were taken with the compass. The topographer always carried a barometer to get the elevation of the ground, setting the aneroid to correspond with the levels of the line. In this way we were able to get a very fair detailed map of the territory.

Much of this exploration line could be utilized as preliminary when we began running preliminary. In several places we ran two or more exploration lines; for example in trying to decide which side of a lake offered the better encouragement for preliminary. Large lakes which we crossed or ran near were traversed with the stadia; we probably ran some 30 miles of stadia in traversing lakes, etc. One particular party chief used stadia entirely for running his exploration lines, dividing his party into two, using two transits, and in this way he could run three to four miles of exploration line a day.

In our stadia work we were able to take some very long sights on the lakes. I remember one sight I took myself of 4,200 ft. with an ordinary transit, setting a hub and reading the rod successfully. In such long sights we read but half the rod reading; that is, the rod distance between the middle hair and the adjacent one. Even with this plan only about 2,800 ft. could be read on a 14-ft. rod. In longer sights than this the rodman held his rod over the top of the 7-ft. picket held vertically. In this way sights as long as 4,200 ft. were read. Sometimes the rod was held on top of high trees, the center hair of the telescope was focused on the top of the rod, the lower hair coinciding with some bright target held on the tree, and the distance between the top of the rod and the target was measured with the rod. The motions of the transitman were made by appealing gestures with some material that could be observed by the rodman a long distance, so that the target could be accurately placed, in many cases, a mile from the transit.

In winter, when the lakes are frozen, traversing lakes by stadia is very easy, although as long a sight cannot be taken, on account of the snow on the ice, as in summer, using canoes.

An obstacle in our work was the difficulty of getting the lines of the adjacent parties tied together without prohibitive elbows or off-sets. If one party got a good line 10 miles south of the adjoining party and that party could not find an available line anywhere else, much of the lines, at the ends, would have to be abandoned, and a new one tried to suit the ground of the adjacent parties. On this account we were forced to abandon some 15 miles of good line, at one end, because the party adjoining us could not find a good line to continue it in his territory.

Having our exploration line completed and a good reliable map of the territory for a considerable, though variable, area, we had almost all the data required to begin running preliminary and could almost project a preliminary on the map of the exploration line and area of adjacent country mapped.

As our exploration survey was in reality a preliminary, though it did not form the base for contours, in running back over it on our preliminary survey we often could use a mile or two of the exploration work by simply rechaining, checking up the angle points and taking contours. With ordinary grades our exploration line would make a good preliminary all the way through; but we were limited to 0.4% grades one way and 0.6% the other and 4° curves. These conditions demand very carefully chosen ground, even in the best country, so that in several places we were forced to run two or three preliminaries for a few miles. Contours were ordinarily taken for 300 ft., on either side of the line, but at high points we had 5-ft. contours taken, in solitary cases, as far to each side as 700 ft. The wisdom of this policy remains to be seen when we begin locating from the projected location map.

Being on a high elevation, 1,300 to 1,500 ft., this country is decidedly cold. Winter really set in on Oct. 15, with snow which never wholly left afterward, and the smaller lakes froze, so that after Oct. 22 canoes could not be used any more and snow shoes and toboggans took their places. As the country is mostly lake and portage, dogs come in for locomotive purposes. A team of five dogs will draw 500 to 600 lbs. at moving-camp time, with the help of the men on the bad places and

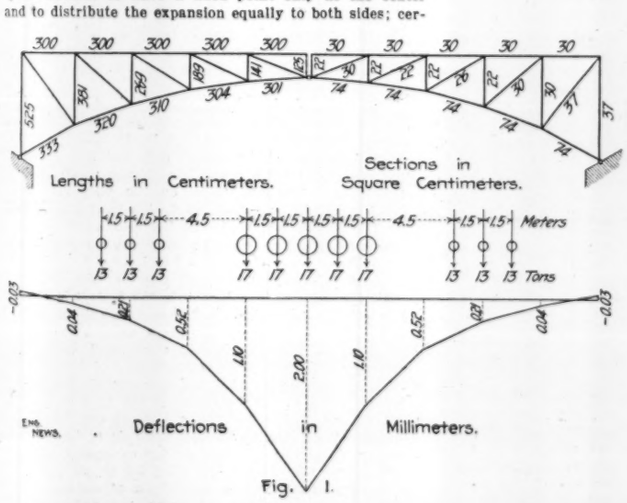


Fig. 1.

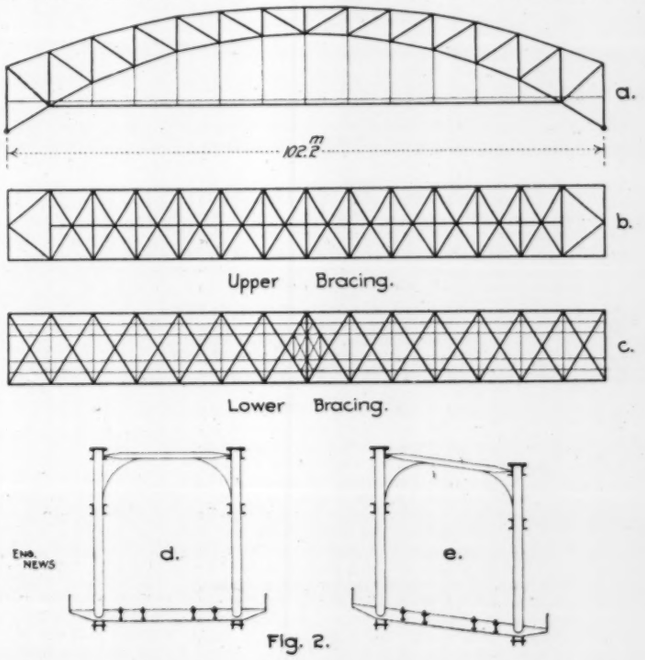


Fig. 2.

rising grounds. We were late in getting the dogs, and for three moves—a total of 18 miles—we moved by hand, two men to a sled or toboggan. Two men with a toboggan could draw 300 lbs. At one time our provisions and other supplies had to be drawn by hand from the caché in this way, a distance of 25 to 35 miles. Every man in the party wears snow shoes on the line and in packing. Without snow shoes it would be very slow walking in the deep snow. There is about three feet of snow now, but when one wears snow shoes 3 ft. is the same as 6 ft. In exploring the first man ahead has heavy walking, but when two or three men pass along a trail the path is fine for walking or for toboggan. The days here are pretty short now, and we pike for the line some time before day so as to get to work on the line by daylight.

We have not found ordinary tents at all uncomfortably cold so far, though the thermometer has frequently been lower than — 35° F.

J. A. Macdonald,
Acting Engineer in Charge of Party 1, Dist. F, Canadian Trancontinental Ry. Survey.
Lat. 50° 10′, Lon. 90° 30′, Dec. 30, 1905.
P. O., Nipigon, Ont.

Getting Out of the Bush, Northwestern Ontario.

Sir: About the first days of the new year the writer, who for the past seven months had been out with a party on the Transcontinental Railway Survey in the northwestern confines of Ontario, decided to go out. A new transitman having come up with the mail, I left him in charge and started for civilization. Accompanying me was the old transitman, the head-chainman, head-axeman and an axeman and packer. It was a long, weary journey of some 180 miles, over lake and portage, and with no means of conveyance but the mail-man's dog-team. We did not go far when we found that the single dog-team could not draw the pack-sacks of our five men, provisions, etc., besides the mail and outfit. At the first opportunity I hired another dog-team, of six dogs, for $20.

Following a dog-team all day is no fun, I assure you, and we did not try to keep up with it. The teamsters run ahead or behind the dogs. It does not do to walk, as the dogs usually go on a trot or gallop. We therefore arranged with the dog-teamsters to go about twelve miles in the forenoon and then stop and prepare dinner for us, waiting till we came up. In the morning we usually started on the trail a couple of hours ahead of the dogs. They usually caught up to us about the middle of the forenoon and passed us.

We reached here (Nipigon) about eight o'clock Saturday (6th) night, having walked from South Bay (35 miles) that day. It was the biggest day's work in the whole journey. It took us just nine days to come out. We took our time, and I held the mail-men back.

The hardest day we had was the very first day. We had no dinner that day, and it was dark when we reached "Poverty Lodge." Bad as the place is, it was welcome that night. It is, however, about the worst joint we struck on the whole journey. We got away in time next morning, however, and made Paddy McGuire's caché that night—about 25 miles. We happened to meet McGuire, a prospector, on the way, and he gave us privilege "to make" his shack, where there was plenty of provision and dry wood. Had we not known of this way-house, we would either have to stay out without blankets or walk along on an unknown trail "to make" Wabnash, which would take us till nine o'clock at night, provided we did not "give out."

We got to Wabnash early next day, and here we were so done up after being up all night (no bed in McGuire's shack and very cold) that we laid up here till next morning. When we got to the Nipigon House, ten miles distant, about 11.30 New Year's day, the big annual Indian celebration was going on. All the Indians and squaws from the reservation were there, eating and drinking and dancing, so we struck a big time. We were welcomed by D. Murchison, the manager, and given the "freedom of the city," so to speak—eat, drink, dance and be merry. The table was spread all day and the Indians, as well as ourselves, had quite a fill-up. Dancing began in the afternoon and it was kept up constantly till four o'clock next morning, Jan. 2. The only ladies were, of course, the pretty young squaws, and they were out in their best attire. Violin and gramophone music, and three half-bred prompters. The boys danced all they could. We had a splendid time, forgetting our fatigue.

We left Nipigon House on the afternoon of Jan. 2 and made Gull Bay, where we stayed at an Indian wigwam. Joe McDonald, a T. C. R. mail-man, and another man, having made Nipigon House for the celebration, were with us, with their dog-teams—four dog-teams in all. Next night we had to sleep outside, and it snowed. This was a bad night for us, but we kept a big fire on all night. Next morning it was snowing thick from the northwest, and we made with some difficulty Grand Bay, 12 miles. Here we laid up till next morning at the house of the Indian chief, where we were used white indeed.

The Indian chief had a comfortable home, had some cattle and certainly a full larder of everything one would want to eat, including moose meat, whitefish, etc. He was so proud and gentlemanly that he scorned to use our own provision, a supply of which we had on our dog-teams, but used his own chack entirely. He was kindness itself and talked to us hospitably, through his grandson acting as interpreter. To show the bill of fare, I give the breakfast, viz.: oatmeal porridge, moose steak (cooked as only an Indian knows how), bacon, bread, butter, sugar and tea—good enough for a $2-a-day hotel. During the evening the chief asked us if we would like to hear the Indian dance music. We readily agreed. He got over a big drum, and played with a short stick, accompanying this with a song or refrain changing in cadence with the variation of the dance. It was certainly entertaining to us who never heard such music before. To make it more interesting the old chief had his grandson, a most decent and well-educated fellow, give exhibitions of the different kinds of Indian dances. To a tenderfoot these Indian dances seem comical. They certainly required great strength and energy to accomplish.

Our moccasins were wet and flabby and frozen and much the worse for the wear; but the chief cleaned and dried our moccasins, and sewed and repaired them, so that next morning when we started for South Bay, 17 miles distant, they were in fine condition to put on. Next day we made South Bay, 17 miles, which we reached at 2.30, laying up for the night. Here a minister of the Gospel was temporarily in charge, and we shall not soon forget his kindness. The next day we made Nipigon. At any place we stayed—at the cachés, Hudson Bay posts, Indian wigwams—we were used splendidly and provided with the very best quality of chack. We had very fine weather all through. Since landing here the boys are all taking a well-earned rest, previous to our starting for Ottawa, the headquarters of the Transcontinental Railway.

J. A. Macdonald.

Nipigon, Ont., Jan. 9, 1906.

Fire Protection Afforded by the Water-Works Improvements at Fort Meade, S. D.

Sir: I have read with much interest a description of the new water supply works for Fort Meade, S. D., in your issue of Dec. 28, 1905, and would like to direct your attention and the attention of your readers to some points in the description worthy of special note. Particular stress is laid on the fact that the new works are primarily designed for fire protection purposes; the description of the design deals at length with this feature, and it might be inferred that the design would embody provisions ensuring reasonable immunity from fires likely to lead to heavy losses. A study of the data submitted does not, however, seem to warrant such an inference, and I take the liberty of proffering the following remarks as much in the spirit of inquiry as of criticism.

The description states that the buildings to be protected are frame and that "new and costly" buildings are included in this number. Judging from the plan attached, the buildings are fairly well scattered and isolated, and it is also a fair inference that values are not notably high in individual cases, but may yet total a considerable amount in the aggregate, and their destruction may entail much inconvenience and incidental loss. The protection as designed calls for "two streams of water thrown over the highest building."

What are two streams of water? They may consist of anything from 100 to 1,000 gallons per minute. The use of the expression "two streams" is so indefinite that it is very misleading. I have inferred that each stream may be about 250 gallons per minute, that being a stream of moderate quantity, likely to be required for work of this class. The capacity of the mains to deliver water at the buildings of the post is also limited, practically, to the amount of 500 gallons, or two 250-gallon streams, which also substantiates my inference.

Now, two streams for a post of this size would appear to be a very scanty amount to cope with even a moderate-sized fire. Any single building of fair size may require all of this or much more for fire extinguishment, and when it is remembered that a single large fire may require not only water needed for extinguishment but possibly, also, an equal amount for the wetting down of adjacent premises to prevent further spread, the meagerness of the protection becomes still more apparent. If water is being used for other purposes, or running to waste, simultaneously with the occurrence of a large fire, during high winds, when large burning embers are widely scattered, the extreme paucity of a 500-gallon a minute supply is still further accentuated. Without any personal knowledge of the situation I would hazard a guess that 1,000 gallons per minute would prove to be none too much for such an emergency. Why not be on the safe side when designing new works such as this for government use? A designer of a bridge or building does not think of preparing a design without allowing a reasonable factor of safety; why should not the fire protection engineer do likewise? He may not require as large a margin as the structural engineer does, but certainly should be a margin of some kind.

The description states that the pipe mains "are connected in circuit to afford good circulation," but the plan attached shows distinctly that nearly one half the distribution system is practically on "a dead end" so far as the high pressure supply is concerned. This might have been avoided by inserting a connection some 200 or 300 ft. of main near the westerly end of the parade ground.

The inadequacy of the 8-in. supply main is obvious from the following approximate estimates of the friction losses in cast iron pipe of such length (approximately 4,500 ft., from profile.) These estimates allow for the inevitable fouling of the inside of mains and are based on actual experiment with pipe in everyday use:

Friction loss with discharge of 500 gallons per minute, 33 ft. static head.

Friction loss with discharge of 750 gallons per minute, 80 ft. static head.

Friction loss with discharge of 1,000 gallons per minute, 140 ft. static head.

The total available head is about 220 ft. from the reservoir to the lower end of the 8-in. main, so that the losses incurred in the supply main are thus wholly unwarranted. From the lower end of the 8-in. main a loop of 6-in. main extends for a length of about 5,000 ft. around the parade ground, and again another loop of about 3,000 ft. encloses another section to be protected. The friction losses that would result from these great lengths of small-sized mains will probably be equivalent to not less than from 40 to 160 ft. of static head, with discharges of from 500 to 1,000 gallons per minute. Thus the total friction losses may be from 50 to 300 ft. static head, with the above delivery; the actual available head is only about 220 ft. Of course, new clean pipe will give greater effectiveness than the above figures show, but the future has to be provided for as well as the present.

I believe that work of this kind, built by the government, presumably with ample funds readily available for first class work, should embody at least complete provision for protection. Many people consider that government work is a standard and a model for others to imitate, but in this case, unless I am imperfectly informed as to facts, it seems to me the system has been designed on poorly conceived lines which might be perhaps excusable to some extent in some small village water-works plant where both talent and means are scarce, but is wholly unjustifiable in the case described. I also believe that a full and frank criticism of a matter of this kind is warranted, and may be of service to the readers of your journal, and may also bring forth additional information from the parties interested of still greater service.

Yours respectfully, E. G. Hopson,
Late Ch. Engr., National Board of Fire Underwriters.
573 W. 146th St., New York City, Jan. 1, 1906.

(Mr. Lea's reply to this letter follows.—Ed.)

Sir: I have your favor enclosing proof of Mr. Hopson's criticism upon the water supply system at Fort Meade, S. D., and thank you for the opportunity of replying thereto.

Briefly stated, Mr. Hopson's objections to the design of the system are the following: (1) The small size of mains. (2) Mains not connected in circuit.

I will dispose of the second objection first by stating that the mains are connected in circuit, as stated in my description. The connection on the west side of the parade ground was not shown on the tracing from which the illustration was made, having been omitted through inadvertance. The omission was not corrected, as it should have been, the writer not having an opportunity to check this tracing before it was mailed.

Mr. Hopson's main objection to the system is the small size of the mains, which he considers inadequate for proper fire protection. He gives some figures, which he says are based on actual experiment with pipe in everyday use, in support of his theory of inadequacy.

Mr. Hopson states that the capacity of the mains to deliver water at the buildings of the post is limited to 500 gallons or two 250-gallon streams per minute. He further states that any single building of fair size may require all of this or more for fire extinguishment.

From my own figures, allowing for rough pipe, I find a delivery of 800 gallons per minute at any point within the area requiring fire protection, not extending, however, to the extreme limit of the system, beyond all buildings. This would afford four strong hydrant streams each of 200 gallons per minute.

I will admit that a water supply of 1,000 gallons per minute is better than one of less amount. Similarly, a supply of 1,500 gallons per minute would be more effective in fighting a fire than one of 1,000 gallons, and so on. It is necessary, however, in making an intelligent design for a water supply system to take into consideration all local conditions affecting actual requirements. With this end in view it can be readily seen that a design for a water supply system suitable for an army post

like Fort Meade would not necessarily follow a cast-iron rule applicable for cities, towns or densely populated areas.

While, as stated in the description, the writer did not design the water supply system for Fort Meade, he supervised its construction and satisfied himself by examination and by consultation with an eminent authority on the subject that the system as designed is fully adequate for the purposes for which it is intended.

The actual conditions that obtain in the case under consideration are as follows: Fort Meade is inhabited by a large number of disciplined soldiers, who are provided with fire-fighting apparatus and are exercised in "fire drill" at least once a month. The military requirements of frequent inspections of quarters and the maintenance of guards and sentinels around the post are effective in the prevention and also in the early discovery of incipient fires. The buildings in the post have been erected under careful supervision; they are constructed of selected materials, in a substantial manner, and all necessary precautions have been taken to prevent the inception or spread of fire within them.

Finally, each building is isolated; the minimum distance between smaller buildings is 60 ft. and that between larger buildings is 75 ft. The buildings are of moderate height, none exceeding 46 ft. from ground to roof peak, and the majority of them being less than 40 ft. high.

It is evident, even to non-technical observers, that under the conditions above stated there is no danger whatever of a general conflagration such as occasionally happens in a city where conditions are entirely different.

In conclusion, the writer will state that it is his unbiased opinion that, if due allowance is made for favorable local conditions, it will be seen that the water supply system of Fort Meade, instead of being "designed upon poorly conceived lines," is fully adequate for all demands likely to be made upon it.

Yours truly,

Samuel H. Lea.

Sturgis, S. Dak., Jan. 20, 1906.

Bauxite as a Material for the Manufacture of Fire Brick.

Sir: Bauxite is a hydrated oxide of aluminum corresponding to the chemical formula Al_2O_3, $2H_2O$, although the proportion of water varies greatly and the aluminum is sometimes replaced by iron. Silica and titanium oxide occur as impurities; silica varies widely in different deposits. Other oxides of aluminum containing water are diaspore (Al_2O_3, H_2O) and gibbsite (Al_2O_3, $3H_2O$). These are found in small quantities, however. The anhydrous oxide of aluminum, known as corundum (Al_2O_3) is found in still smaller quantities than the above, so that bauxite is the only oxide of aluminum found in considerable quantities. There are three localities in the United States where bauxite has been found in commercial deposits, viz., in Arkansas, New Mexico and the Georgia-Alabama district. The last named district has probably been worked out by this time, and at present the chief sources of the ore are the Arkansas deposits.

The crude bauxite is washed at the mines to remove some of the free silica. It is next calcined at a temperature of 2,500° F. approximately Seger cone 12, and during this process it gives off its chemically combined water, amounting to about 30% of the raw ore, and also undergoes great shrinkage. It has been observed that the bauxite shrinks very little until after Seger cone 9, approximately 2,390° F. is reached, and from Seger cones 9 to 12 the greatest amount of the shrinkage takes place. Accordingly, the lowest temperature limit at which bauxite should be calcined is 2,500° F.

An analysis of washed calcined bauxite from Arkansas made by the writer is as follows:

Mechanical water	0.88%
Silica	6.40%
Oxide of iron	1.43%
Alumina	87.30%
Titanium oxide	3.99%

The calcined material can be bonded with fire clay, sodium silicate, or lime and made into brick and tile. As little as 4% plastic fire clay can be used for a bond for hand-made brick. When bonded with lime the brick become quite hard a few hours after making, so hard that they will not take the impression of the finger nail. This setting or hardening is probably due to the formation of a calcium silicate between the lime and the free silica analagous to the setting of silica brick when bonded with lime. After a careful drying treatment the brick are burned in down-draft kilns at a high temperature, and when burned they are hard and tough and can be thrown to the pavement or batted vigorously against one another without breaking. A brick 9 × 2½ × 4½ ins. weighs 7½ lbs. and stands a crushing test of 10,000 lbs. per sq. in.

The problem of calcining the washed granular bauxite presents itself. The material cannot be successfully calcined in a vertical shaft kiln because it will pack and clog on account of its fineness and so obstruct the passage of the kiln gases. On the other hand, it is not feasible to calcine it in the ordinary down-draft kiln on account of the perforated floor. The writer believes that to calcine it on a commercial scale would require a rotary kiln using oil, gas, or powdered coal for fuel, preferably the former. Provided the cost of fuel is low at the mines these kilns should be installed there in order to save the cost of transportation which is now paid on the 30% of water that the crude bauxite contains.

For basic open-hearth steel furnaces a brick high in alumina and low in silica is required. A brick of this character is obtained in the following way: A pure white variety of the pisolitic bauxite which has already been washed at the mines and a portion of its free silica removed is selected and sieved. All the flue material passing through the sieve is rejected, as it contains the greater part of the silica; the pisolites or pebbles about the size of peas are retained as they are higher in alumina and freer from silica than any other part of the bauxite. Now, by using lime selected for its freedom from silica as a bond, a brick can be procured which will contain as low as 6% or 8% silica.

A high silica content has always been the chief objectionable feature of bauxite brick for basic open-hearth steel furnaces because the silica is attacked by the basic slag. Authorities on open-hearth practice have generally declared that bauxite brick would be suitable for basic open-hearth furnaces provided a brick could be made with less than 12% silica content, and recent tests made along this line seem to bear out this statement.

A test was made several months ago in one of the basic open hearth furnaces of the Bethlehem Steel Works, in which a bauxite and a magnesite brick were placed side by side near the gas and air ports and submitted to the highest temperature attainable in the furnace. The magnesite brick bent and showed viscosity after a period of seven minutes against a period of fifteen minutes for the bauxite brick. Again, a magnesite brick and bauxite brick were bathed in the slag near the doors for some time, after which they were withdrawn and examined when cold. The magnesite brick was incorporated with slag, while the bauxite when broken open showed that the slag had not penetrated to its center, but had remained as a coating over the outside. Both bricks were quite badly affected, but it was readily apparent that the bauxite withstood the action of the corrosive slag equally as well as the magnesite. More recent tests with brick having a lower content of silica have also shown bauxite to be equal to magnesite when exposed to the action of the basic slag. The comparison is hard to make in any case because of the fact that either bauxite or a magnesite brick, if left in the hearth of the furnace for any length of time and submerged in the slag, is so violently attacked that the differences in the portions that are taken out are not easily detected. Even a magnesite brick if thrown into a basic open-hearth furnace will be entirely eaten away after a considerable length of time, so that the only real test of bauxite brick will be to build a hearth or portion of hearth out of these brick and test them, covering them with calcined bauxite and treating them in every way like the magnesite hearths are treated. Some steps are now being taken towards carrying out tests of this character.

Sir Wm. Siemens found that bauxite was a superior furnace lining and, even though he used an inferior bauxite containing as much as 35% oxide of iron, he claimed they lasted five or six times as long as the "Stourbridge First Brick." Siemens also says of bauxite: "It is important to observe that bauxite when exposed to intense heat is converted into a solid mass of emery of such extreme hardness that it can hardly be touched by steel tools and is capable of resisting mechanical as well as the calorific and chemical action to which it is exposed." Bischof, in his "Feuerfesten Thone," says that bauxite, "when not impure on account of the admixture of foreign substances, especially of iron which generally occurs in considerable quantities in compounds of aluminum, is extremely refractory." He also goes on to say, that "The addition of varieties free from iron, or the white ones, to other refractory clays offers the only important means known of increasing their percentage of alumina, and at the same time their refractoriness." It appears then that bauxite has been regarded as a refractory material for a long time, but that no definite use has been made of it, also that the inferior grades have been more generally tested than the purer ones.

Other than its uses for open hearth furnaces (which by the way is being thoroughly exploited and investigated to make certain of its fitness before taking any risks) bauxite brick has shown up quite successfully in other lines. Two recent applications are its uses, first, as a lining for rotary Portland cement kilns, and, second, as a lining for lead-refining furnaces.

As a lining for a rotary Portland cement kiln it has shown unusual durability and has given excellent service. As an experiment, the hot zone (about 10 to 12 ft.) of a 60-ft. rotary kiln fired with coal dust was lined with 6-in. bauxite lining whereas the kiln had previously been lined with 9-in. fire-brick block. A block for lining rotary kilns in the hot zone must possess the following qualities: It must neither be too hard or too soft, for if too hard it will not allow the cement coating to stick to its surface, and if too soft it will not hold the coating, but the latter will pull off bringing portions of the brick with it. The cement coating affords an excellent protection for the lining, and if brick do not hold this coating they soon burn out. The bauxite block made for this purpose has all of these qualities. After ten months continuous service night and day this 6-in. lining is still doing the work. The loss of output in cement, for every 24 hrs. that one of these rotary kilns shut down, is equivalent to the sum of $250. As the minimum time required for lining or patching a kiln in the hot zone is from 36 to 48 hours, one can easily estimate that the loss of output will be equivalent to a sum varying between $375 and $500. In this case it is quite apparent that a superior lining will be the cheaper in the long run. Again it must be remembered that only the hot zone need be lined with a bauxite block.

The second and most recent applications of bauxite brick has been that of lining portions of lead-refining furnaces. Pig lead containing copper, antimony and occasionally arsenic and other metals in small quantities, is charged into the hearth of the refining smelter and melted by the reverbation of hot gases from above. The hearth of the furnace, which is 10 by 13 ft. in dimensions, is lined on the bottom by 9-in. square brick set on end. The sides of the furnace are lined with a single course of 9-in. brick laid with ends against the walls. The temperature of the furnace is 1,300 to 1,400° F., and outside of the part it plays in melting the fluxes, bears no relation to the destruction of the brick, as they are sufficiently refractory to withstand much higher temperatures. It is purely a case of chemical action on the brick. During the process of refining, a scum rises to the surface of the molten lead, and this scum contains most of the impurities which the refining is designed to remove. It consists largely of litharge or yellow oxide of lead, copper oxide, and antimony oxide, with possibly other oxides in much smaller amounts. Wherever the bricks are exposed to this scum, particularly around the doors, where there is a larger supply of oxygen, and accordingly litharge is more easily formed, and along the level of this scum, they are badly eaten away and have to be taken out after several weeks service, and generally have to be patched after a week has passed. Consequently the furnace loses much time for repairs, which lowers its output considerably.

The cutting away of the brick is explained as follows: Multiple silicates are formed between the oxides of the metals in the scum and the silicates of alumina and free silica in the brick, and these are very fusible, because lead oxide, PbO, which is one of the most fusible of the oxides, comprises the greater part of the base of the silicate. But there are also several other oxides in the base of the silicate, and it is quite well understood that multiple are more fusible than single silicates. Hence as very fusible silicates are formed between the scum and the fire brick, the brick are very rapidly decomposed and eaten away. It was observed that a porous brick wore out faster than a dense brick; also that the scum penetrated along the joints for several inches beyond the exposed face of the brick. This is probably due to the fact that the raw fire clay which was used in making the joints is much more soluble in the scum than the burnt clay. Accordingly great care should be taken in laying up the brick to see that the joints are as tight as possible.

As the scum was composed of highly basic oxides it was considered reasonable to supplement a basic lining for the fire brick lining and according a lining of bauxite was put in wherever the brick were exposed to the slag. The result was that the bauxite brick lasted from five to six times as long as the fire brick lining.

With its above mentioned uses and its possible advent into open hearth practice and elsewhere, the writer feels that bauxite brick will at some future date be one of our most valuable and useful refractory materials.

A. J. Aubrey,
Chemist, Laclede Fire Brick Mfg. Co.

St. Louis, Mo., Jan. 10, 1906.

Notes and Queries.

The correspondent in Eshore, Zululand, who inquired for information as to current wheels will find some rather crude illustrations of home-made wheels in a monograph entitled "Some Methods of Lifting Water in Nebraska," by Erwin H. Barbour, printed in the report of the Nebraska State Board of Agriculture for 1899.

We break our usual rule not to publish anonymous communications in order to print *verbatim et literatim* the following:

Dear Sirs.

In regard to the poor saleries paid engineers, will say that I left the profession because of this fact.

I think that the higher engineers of this country have it in there power to improve things wonderfully if they would. The saleries of the under men are usualy left to them. Why can they not put the profession where it should be, in the matter of wages?

Yours very truly,

"Has-Bin"

The higher engineers are "usualy" glad to help "there" assistants who complain of poor "saleries" to get out of the profession.

C. E. B., New York City, writes:

An architect designing a small manufacturing plant in this city proposes to run machinery by electricity made on the premises by steam boiler, engine and generator, instead of employing the usual shafting run by a steam engine. Do you think it would pay or even be as cheap

as the old way, of steam engine, shafting and belt transmission of power throughout the factory?

For small plants, certainly, the first cost of the belt transmission would be much less than the cost of electric transmission. (See letter on p. 44 of our issue of Jan. 11.) It is difficult, however, to lay down general rules to solve problems of this sort. The uses to which the factory is to be put, for example, may practically dictate the use of electric motors, and conditions of current supply may make an independent electric plant more economical than the purchase of current.

A NEW POSITIVE-PRESSURE BLOWER.

A new form of positive-pressure blower has recently been developed by the B. F. Sturtevant Co., builders of centrifugal fans and fan machinery, at Boston, Mass. It consists, like other positive blowers (and rotary pumps), of two revolving cylinders mounted on parallel axes and meshing with each other, contained in a housing in which they revolve with only sufficient clearance to avoid rubbing friction. The motion of the rotors creates pockets or chambers between them, which pockets increase and decrease in size, so that air is drawn in through suitably disposed ports, is compressed, and is then discharged through other ports in the housing. The pressure of the entrapped air acts on the leading side of each rotor and opposes its rotation; power must be applied to the rotors to turn them against this one-sided pressure. The shafts of the two rotors are geared together, outside of the housing, to make the rotors revolve at equal speed. Usually, one of the shafts is connected to the source of power, and in turn drives the other rotor through these gears.

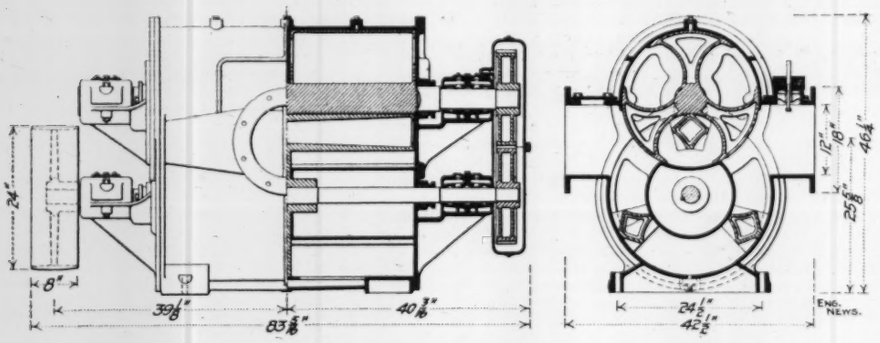


FIG. 1. THE NEW STURTEVANT "HIGH-PRESSURE" BLOWER; TRANSVERSE AND LONGITUDINAL SECTIONS.

Dimensions are for No. 8, Capacity 3,000 cu. ft. air per min. at speed of 330 r. p m.

The new Sturtevant blower has the peculiarity that the work of moving and compressing the air is done wholly by one rotor, and the other rotor takes only the power needed to overcome its journal friction. The gears which connect the shafts are thus relieved of all but a small fraction of their usual duty, and the machine operates with correspondingly reduced noise and increased efficiency.

The construction of the "high-pressure" blower, as it has been called, is exhibited by Fig. 1, where are shown transverse and longitudinal sections of the complete machine. Fig. 2, giving views of the rotors (impeller below, idler above), will assist in obtaining a good understanding of the construction. It will be seen that the impeller consists of three longitudinal blades surrounding a cylindrical core; but as this core has a part of its circumference cut away where the circumference of the idler intersects it, the core must be stationary instead of rotating with the blades of the impeller. The blades are therefore carried on a radial web-plate mounted on the middle of the shaft; three blades project from either side of this web. The core is necessarily made in two parts, because of the impeller web; each half forms an inward extension of the corresponding end plate of the casing.

The idler is a cylinder containing three deep longitudinal slots or chambers of suitable form to receive and pass the blades of the impeller as the rotors turn. The openings of these slots on the idler periphery are made as narrow as possible; when a slot faces the impeller shaft the stationary core of the impeller case completely covers the slot opening and prevents direct communication between suction and pressure sides.

In Fig. 3 herewith are represented, by diagrammatic sections through the blower, three successive stages in the operation of the machine. The stationary parts (casing and impeller core) are drawn in black, while the impeller blades and the idler are cross-hatched. The segmental areas L, M, N, O are depressions in the end plates, which in certain positions of the rotors serve as air ports which are important in the working of the blower.

In sketch I, Fig. 3, the inlet pipe at the left is open to space D, between impeller blades A and B, which space is closed off as soon as impeller A reaches the lower edge of the inlet opening. If the speed of rotation is so great that space D is not filled to atmospheric pressure by the time it is closed off, then additional air will flow through the depression or "leakage port" L into space D, until the position of sketch II is reached, where port L is just cut off. Continuing just beyond this position, impeller blade B uncovers the leakage port M, which brings space D into communication with the delivery side, as shown in sketch III, and permits air under delivery pressure to flow back through port M into D, and thus partly compress the charge in D. This is indicated by the dotted arrows at port M in sketch III. This compression continues until impeller blade B reaches the lower edge of the delivery opening, after which blade A sweeps the charge in D out into the delivery pipe. This stage is represented by the condition of space E between blades B and C in sketch I, Fig. 3. Here the slot Z of the idler is coming into position to receive blade C. Shortly after this stage the port O makes leakage connection between slots Z and Y, and pressure air from Z flows into Y, thereby compressing the atmospheric charge in Y. In sketch II the end of this stage is nearly reached; just afterward slot Z is completely closed off by the impeller core. The remaining flow through port O from Z to Y reduces the pressure in Z, so that when Z opens to the delivery side, as in sketch III, wasting its contents into the inlet opening, the loss of compressed air is lessened by the amount which Z previously gave to Y.

Thus the work of compressing air is done wholly by the impeller blades A, B, C. The idler acts only as a valve or air-lock to pass the impeller blades back into the delivery space, and in doing so actually returns compressed air to the inlet side. This loss is reduced, of course, by making the size of the slots X, Y, Z a minimum; in other words, making the idler as small as possible compared with the rotor. That the idler does no work on the air is made apparent by noting that in all positions the air pressures act radially on the idler, so that its rotation does no work against the air.

Referring now to the construction side in more detail, the clearances of the moving parts engage attention. The clearance between impeller blades and idler is ample at all points—in small blowers at least ⅛-in., and in large blowers ½ to ¾-in. The clearance between either end plate and the casing is made as small as possible, never over 0.03 in., just enough to give substantial clearance. The end clearances are even less.

The surfaces of impeller, idler and end plates (including impeller core) are finished either in the lathe or on the boring mill. The idler is finished on its outer surface only (not in the slots). The impeller blades are finished on outer and inner edges and on the ends. The central web-plate of the impeller is faced by the use of special attachments to lathe and shaper. A central partition in the idler casing closes off that portion of the groove in the middle of the idler which is not closed by the impeller web.

Two general styles of the machine are built; in one the idler and impeller lies in the same vertical plane, the idler being above (as shown in Fig. 1), while in the other type they are in a horizontal plane. The machine is of cast iron throughout, except for the steel impeller shaft. The idler and its shaft are a single piece of cast iron.

Figs. 4 and 5 are two views of the blower, one showing the parts before assemblage and the other showing the complete machine. In Fig. 4 the shape of end plates and impeller core is made evident. Different methods of providing bearings are shown in the two views. In Fig. 4 the bearings are in brackets cast on the end plates, while in Fig. 5 the bearing brackets are bolted on; the latter construction is used for very large blowers. In all cases the bearings are lined with white metal hammered in and bored, and have ring oilers. The gears are surrounded by a casing and run in oil.

These blowers are reversible, running equally well in either direction. This explains why leakage port N, Fig. 3, is provided, though it has no function when the machine is running in the direction there show. When it is desired to maintain the delivery pressure quite constant, a relief valve is fitted on the delivery side (see Fig. 1). For transferring gases and air at high pressure, stuffing boxes for the shafts are provided in the end plates; a drain in the bottom of the casing removes tar and other liquids.

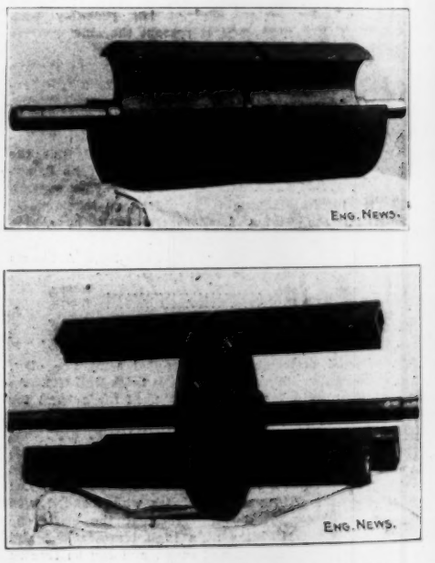
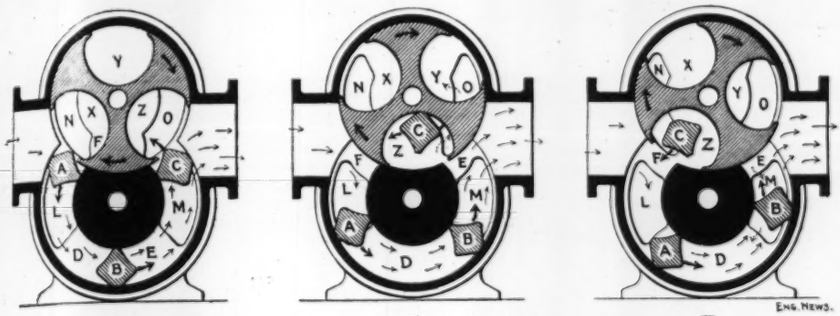


Fig. 2. Impeller and Idler of Sturtevant Positive-Pressure Blower.

These blowers can operate over a wide range of speed. They are intended to work up to pressures of 10 lbs. per sq. in. They are built for capacities up to 15,000 cu. ft. per min., for which latter the length of impeller is about 71 ins., and the speed 250 r. p. m. Such a blower will supply a 90-in. cupola, melting 30 tons of iron per hour.

IRRIGATION AND DRAINAGE INVESTIGATIONS, U. S. OFFICE OF EXPERIMENT STATIONS.

During the past few years there has been built up, under the direction of Mr. Elwood Mead, M. Am. Soc. C. E., a staff of engineers engaged in studies of irrigation, drainage and farm machinery. The larger part of the force is engaged on irrigation work. The investigations of farm machinery are relatively new, and thus far they are being carried on principally by one man.



I. II. III

FIG. 3. DIAGRAM SECTIONS OF STURTEVANT "HIGH-PRESSURE" BLOWER, ILLUSTRATING OPERATION.

Most of the work being directed by Mr. Mead is carried on in the field, thus resulting in close study of actual conditions. As the various field men are scattered over a territory 2,000 miles long by 1,000 miles wide, it is desirable that they be brought together from time to time for a comparison of notes and for a discussion of plans for future work. Such a conference was held at Washington, D. C., during the week ending Jan. 23, 1906. A brief outline of the subjects discussed and of some of the work being carried on or proposed has kindly been supplied to us by direction of Mr. Mead, as follows:

The question of unity of methods and of keeping track of the progress of work as it goes on was one of the important subjects to be dealt with in this conference. As a factor in this, the method of keeping and forwarding notes to the central office was one of the first subjects to be considered. It was decided that hereafter all field notes shall be kept in duplicate by means of special note-books provided for making carbon copies. The duplicate copy will be mailed to the Washington office once each week. This will insure the preservation of notes against loss or accident, and enable those supervising the work to advise about methods as the work of the season progresses.

Studies have been carried on during the past season to find out the possibility and extent of irrigation which may be used in connection with dry farming throughout those large areas in the western part of this country where complete irrigation can never be possible on account of a lack of sufficient water supply. This matter received a very full discussion at the conference, and plans were perfected for continuing these investigations throughout the coming season.

Agricultural drainage has, during the last three years, occupied an important place in the work of the office of experiment stations. The work carried on during the last year was reviewed and plans for work during the coming year discussed. Among the larger works taken up may be mentioned the drainage survey covering approximately 2,000 square miles of the level lands of the Red River Valley in North Dakota, the drainage plans for which are now being prepared by the engineer in charge.

Drainage investigations have also been made during the past season in the Kankakee Valley of Indiana, which has a drainage area of 300,000 acres, and is attracting much attention because of its agricultural possibilities and value to both land owners and the state when it has been adequately reclaimed. The work here will be continued during the coming year, from the results of which it is expected that a comprehensive and efficient plan for the drainage of the basin as a whole may be formulated and recommended.

There are localities in the valleys of many streams in the Middle West where the soil, though exceedingly rich, lacks adequate drainage, and which, from its impervious nature, is not supposed to be susceptible of successful underdrainage. Examinations, and in some cases experiments, looking to the solution of these vexed problems have been undertaken and will be closely watched, and the results made public for the information of those owning lands of that character. Experiments of this kind have been installed in the Neosho Valley of Kansas, and in the Yazoo Delta of Mississippi.

There are also problems connected with the management of the lands along the tidal rivers of South Carolina and the rice fields of Louisiana and Texas which are receiving special attention. Also the methods of terracing the hill lands and controlling their erosion by means of ditches and underdrains are subjects receiving special examination, the importance of which will merit further attention.

The methods of drainage of the sugar-cane lands in Louisiana in common use are being examined, with a view to reducing the number and consequent inconvenience of the deep open ditches by supplementing them with large covered drains.

An important feature of the work undertaken by this office is that relating to drainage of water-logged lands in irrigated regions of the West. During the past year drainage experiments have been installed in the state of Utah for determining the best methods of relieving seeped lands. This work is done with the cooperation and assistance of the state and presents many perplexing and as yet unsolved problems. The same is true of work which has been undertaken at Brownsville, in southeastern Texas, for the relief of fertile soils in that section from the injurious salt which was developed as soon as irrigation began. Investigations and experiments of a somewhat novel character are now being prosecuted for the solution of the drainage difficulties confronting the owners of land in that section.

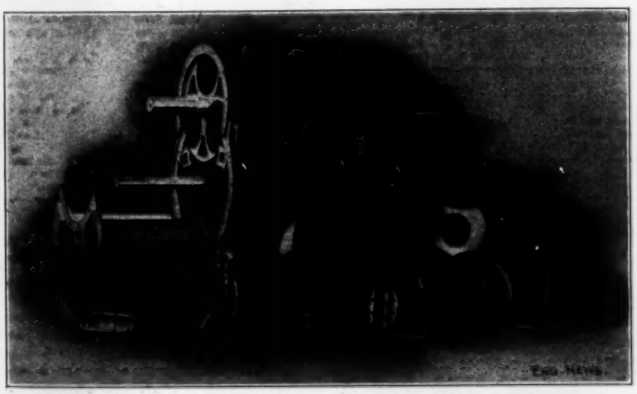


FIG. 4. PARTS OF STURTEVANT POSITIVE BLOWER, VERTICAL STYLE.

A manual of simple directions for the selection and use of pumps for irrigation will be issued. It will be based on a large collection of data accumulated during the past two years, relating to the cost and efficiency of different sizes and types of pumps, working under varying conditions.

Besides Dr. A. C. True, Director of the Office of Experiment Stations, and Mr. Mead, there may be named as among those present at the conference, the following: A. P. Stover, in charge of irrigation investigations in Oregon; Samuel Fortier, in charge for California; Harvey Culbertson, of Texas; H. G. Raschbacher, of Idaho; F. C. Herrmann, of Cheyenne, who has charge of the investigations of irrigation as related to the settlement of the arid region; F. W. Roeding, of Colorado, who has charge of experiments to determine the best methods of irrigating sugar beets; A. E. Wright, of Nevada; W. W. McLaughlin, of Utah; R. P. Teele, of Washington, who has charge of studies of the legal and economic problems of irrigation; S. M. Woodward, of Washington, D. C.; C. G. Elliott, in charge of drainage investigations, and C. J. Zintheo, in charge of the investigations of farm machinery.

ENGINEERING MATERIAL PRICES.

TRACK FASTENINGS—
Pittsburg f. o. b. cars—Angle bars, 1.75 cts.; spikes, 2.10 cts.; bolts, square nuts, 2.55 to 2.60 cts.; bolts, hexagonal nuts, 2.70 to 2.75 cts.

RAILS, STEEL—
New York—at mill—New standard sections $28; standard, second quality, $27; light sections, 12 to 25 lbs., $27.00 to $35.00; old iron, f. o. b. New York, $22.50 to $23; old steel, long lengths, $16.50 to $17.50; old steel, short pieces, $16.50 to $17.
Pittsburg—Standard sections, at mill, $28; standard, second quality, $27; light rails, 12 to 25 lbs., $24 to $30.

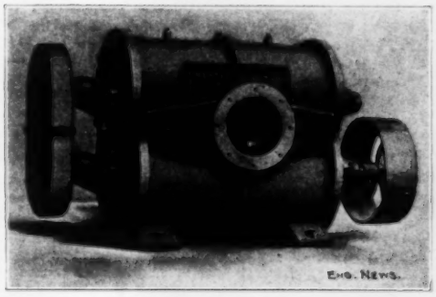


Fig. 5. Sturtevant Positive Blower, Vertical Style, Assembled Complete.

STRUCTURAL MATERIALS—
New York—at tidewater—Beams and channels, up to 15-in., 1.84½ cts.; over 15-in., 1.84½ cts.; angles, 3 × 2 and up to 6 × 6, 1.84½ cts.; zees, 3-in. and larger, 1.84½ cts.; tees, 3-in. and larger, 1.89½ cts.; steel bars, half extras, 7.74½ cts.

PLATES AND SHEETS—
New York—at tidewater—Sheared plates, tank, 1.74½ to 1.84½ cts.; flange, 1.84½ to 1.94½ cts.; marine, 2.14½ to 2.24½ cts.; still bottoms, 2.04½ cts.; fire box, 2.24½ to 2.60 cts.
Pittsburg—Tank, ¼-in. thick and heavier, 1.60 cts.; black sheets, 27 gage, 3.25 cts.; black sheets, 28 gage, 3.45 cts.

IRON—
Pig Iron:
New York—tidewater—Northern: No. 1 X Foundry, $19 to $19.25; No. 2 X Foundry, Northern, $18.50 to $18.75; No. 2 Plain, Northern, $18 to $18.25; Gray Forge, Northern, $17 to $17.25; Basic, Northern, $18.50; No. 1 Foundry, Virginia, $18.60 to $19.10; No. 2 Foundry, Virginia, $18.10 to $18.60; Basic, Virginia, $19.10 to $19.60; No. 1 Foundry, Southern, $18.75; No. 2 Foundry, Southern, $18.25; No. 3 Foundry, Southern, $17.50 to $17.75; No. 4 Foundry, Southern, $17 to $17.25; No. 1 Soft, Southern, $18.50 to $18.75; No. 2 Soft, Southern, $18.25; Gray Forge, Southern, $16.50 to $16.75; Mottled, Southern, $16.25 to $16.50; Basic, Southern, $18.75.
Chicago—Lake Superior Charcoal, $20.50 to $21.50; Northern Coke Foundry, No. 1, $19.75 to $20; Northern Coke Foundry, No. 2, $19.25 to $19.50; Northern Coke Foundry, No. 3, $18.75 to $19; Northern Scotch, No. 1, $20 to $20.50; Ohio Strong Softeners, No. 1, $20.05 to $20.30; Ohio Strong Softeners, No. 2, $19.55 to $19.80; Southern Coke, No. 1, $18.40 to $18.65; Southern Coke, No. 2, $17.90 to $18.15; Southern Coke, No. 3, $17.40 to $17.65; Southern Coke, No. 4, $16.90 to $17.15; Southern Coke, No. 1 Soft, $18.40 to $18.65; Southern Coke, No. 2 Soft, $17.90 to $18.15; Southern Gray Forge and Mottled, $16.40 to $16.65; Malleable Bessemer, $19.25 to $19.50; Standard Bessemer, $19.55 to $19.80; Jackson Co. and Kentucky Silvery, 6%, $21.30; Jackson Co. and Kentucky Silvery, 8%, $22.30; Jackson Co. and Kentucky Silvery, 10%, $24.30.
Pittsburg—f. o. b. cars—No. 2 Foundry, $18.35 to $18.85; Gray Forge, $17.35; Bessemer Iron, $18.60; Ferro-Manganese, $125 to $150; Muck Bars, $32; Iron Bars, $1.90.

Cast-Iron Pipe:
New York—Carload lots, net tons, 6-in., at tidewater, $29.75.
Chicago—4-in. water pipe, $31; 6-in. and larger, $30, with $1 extra for gas pipe.

MISCELLANEOUS MATERIALS—
Asphaltum:
Ventura and other California asphalts, $19 to $21 per ton at New York; Trinidad refined, $20 to $25 per ton; Venezuela asphalt, $25 to $30 per ton; Bermuda asphalt, $25 to $30.

Cement:
Rosendale or Natural, in wood, 85 cts. per bbl.; Portland domestic, in sacks, $1.15 to $1.20; in wood, $1.50 to $1.60; German Portland, $1.90 to $2.10.

Copper:
Lake, 18 to 18¼ cts.; electrolytic, 18 to 18¼ cts.; casting, 18 cts.

Lead:
New York, spot, 5.70 to 5.75 cts.

Spelter:
New York, spot, 6.15 to 6.30 cts.

Tin:
New York, spot, 36.35 cts.

Tar:
New York, $5 to $5.50 per bbl.

Pitch:
New York, $3 per bbl.

LUMBER—
New York, wholesale prices:
Piling—Spruce, ordinary cargoes, 6 to 7 cts.; oak, 14-in. butt, 40 to 50 ft., 19 cts.; 50 to 55 ft., 22 cts.; 55 to 60 ft., 23 cts.; 60 ft. and up, 25 cts.; pine, 60 to 65 ft., $8.50; 65 to 70 ft., $9.50; 70 to 75 ft., $10.50; 80 ft. and up, $16.
Railroad ties—Yellow pine, 6 × 9 ins. × 8 ft., 65 to 66 cts.; 6 × 8 ins. × 8 ft., 59 to 61 cts.; 7 × 9 ins. × 8 ft., 72 to 73 cts.; 7 × 8 ins. × 8½ ft., 68 to 69 cts.; 7 × 9 ins. × 8½ ft., 73 to 74 cts.

THE FASTEST MILE EVER TRAVELED on wheels was recently made by a steam-driven automobile in the automobile races on the Ormond-Daytona course in Florida. The time as indicated by the electrical timing device was 28⅘ sec., or at the rate of 127.66 miles per hour. The car which made this phenomenal record was designed by Mr. F. E. Stanley, of Boston, and is of rather peculiar construction, resembling an inverted racing shell upon four wheels. It has the appearance of a huge cigar, with only the head of the driver appearing above the covering of the car. The engine has two cylinders and is rated at 50 HP. The boiler is of the round tubular type and develops a steam pressure of from 500 to 800 lbs. per sq. in. It is said that the car is capable of developing 100 HP. for short distances.

A BOILER EXPLOSION in the power and heating plant of the Windermere Hotel, Chicago, occurred Jan. 21, killing the engineman and causing considerable damage to property. The boiler is said to have been 12 years old, but was inspected in February, 1905, and again in March after certain repairs had been made. At that time also the safety valve was sealed to blow off at 80 lbs. instead of 85 lbs., and the later inspector who tested the valve after the explosion stated that it opened freely at 80 to 81 lbs. The heating plant had been enlarged, and it is said that a new boiler had been ordered, but that in the meantime the old boiler had to be worked harder than usual to supply the required amount of steam. The boiler inspector, however, states that, in his opinion, the engineman opened the stop valve too quickly when starting the engine.

THE FOUNDATIONS OF THE STATE CAPITOL at Albany, N. Y., are exhibiting signs of serious weakness, and an investigation of the cause has been made in behalf of the Trustee of Public Buildings by State Architect Geo. L. Hines, assisted by Messrs. Wm. Barclay Parsons and Daniel E. Moran. These gentlemen have reported as follows:

After our examination of the Capitol it would appear that the causes are disconnected with the staircase itself.

The staircases are at the point of the greatest structural weakness. The situation is one of great complications, as involving the integrity of the building as a whole.

To bring about the removal of the cause or make the proper correction a thorough investigation of underlying conditions would seem to be necessary. This would mean a survey of the whole building.

In this work there would probably have to be an examination of the foundation of the test pits and also a determination of the geological strata on which the building rests. Such investigation would necessarily occupy considerable time and involve an outlay of money.

We believe the public should be excluded from the general use of the staircase. It is evident that the actions that have caused the damage to the staircase are still in force and that the component parts of the staircase are under great internal stress. In addition to weakness in the staircase itself certain parts show a decided tendency to spall. Persons using the staircase are exposed to the double danger of a serious collapse of the structure or being hit by small pieces becoming detached.

FIRE AT THE U. S. NAVAL TRAINING STATION, Coaster's Harbor Island, near Newport, R. I., on Jan. 27, destroyed seven buildings, including machine, carpenter and paint shops. An effort to put out the fire by a bucket brigade failed and aid from the Newport fire department was asked. The estimated loss of buildings, stores, etc., is $100,000.

THE FAMOUS OLD LOCOMOTIVE "Reuben Wells," built in 1868 for the Madison Hill Incline of the Jeffersonville, Madison & Indianapolis Ry., has been presented to Purdue University for its Railway Museum. An illustrated account of this noted locomotive appeared in our issue of June 10, 1897, being contributed by the late Edward Grafstrom, the young motive power engineer who met an untimely death while engaged in the heroic work of saving lives in the flood at Topeka, Kan., three years ago. This locomotive was designed by Mr. Reuben Wells, when Master Mechanic of the old J. M. & I. Ry., which is now a part of the Pennsylvania system. It is notable as being among the very earliest of heavy locomotives, and it was so well designed and well built that it continued in regular service until 1896, since which time it has been kept as a reserve. The locomotive as originally built weighed 112,000 lbs., all of which was carried on five pairs of driving wheels. In 1886 it was remodeled and the rear pair of drivers was removed. For further description of the locomotive and of the famous 5.9% incline, reference should be made to Mr. Grafstrom's article.

A LARGE ROUNDHOUSE with locomotive drop-pits of novel design and equipped with an overhead traveling crane has been built in connection with two new yards of the Pennsylvania R. R. at East Altoona, Pa. The roundhouse is a complete circle 395 ft. in diameter, with 52 stalls 90 ft. deep, and is served by turntable 100 ft. in diameter. The main portion is 65 ft. wide, with a 60-ft., 12½ ton crane, while parallel with this is a lean-to span in which the smoke-jacks are located. There are four drop-pits, one large enough to take all driving-wheels at once, two for single pairs of driving-wheels, and one for truck wheels. The table of each pit is operated by vertical screws working in nuts revolved by worm-wheel gearing, the screws descending into iron pipes sunk below the floor of the pit.

EXPERIMENTAL LOCOMOTIVES of five types are in use in passenger and freight service on the Pennsylvania R. R. in order to obtain practical information as to the merits of certain features and the desirability of making any changes in the designs before ordering new locomotive equipment. There are two engines for each type, one operated on the Pennsylvania R. R. and the other on the Pennsylvania Lines. One of the types is the De Glehn four-cylinder compound balanced engine purchased in France and exhibited at St. Louis in 1904. There are also two other four-cylinder balanced engines of American construction (all these three being of the Atlantic or 4-4-2 type for passenger service). The others are an engine of the Pacific or 2-6-2 type and a consolidation, or 2-8-0, engine. These two are simple. The engines were built to the general designs of the motive-power officials of the Pennsylvania R. R.; all have piston valves, and the French compound and Pacific type simple engines have the Walschaert valve gear. The general dimensions of these engines are as follows:

Service	Passenger*	Passenger	Passenger	Freight	Freight
Type	4-4-2	4-4-2	4-4-2	2-6-2	2-8-0
Compound	4-Cyl. bal.	4-Cyl. bal.	4-Cyl. bal.	Simple	Simple
Compounding system	De Glehn	Baldwin	Cole	....	....
Driving wheels	6-ft. 8¼-in.	6-ft. 8-ins.	6-ft. 8-ins.	6-ft. 0-ins.	5-ft. 3-ins.
Wheelbase, driving	....	....	....	....	....
Wheelbase, total	....	....	....	....	....
Weight on drivers, lbs	85,000	90,500	117,200	167,000	198,000
Weight, total lbs	164,000	196,000	200,000	234,500	220,000
Weight of tender, lbs	132,500	128,100	125,300	130,300	140,500
Cylinders, h.p. Ins	14⅞ x 25⅝	18 x 26	16 x 28	21½ x 28	23 x 32
" l.p. Ins	23⅝ x 25⅝	27 x 26	27 x 28	....	....
Boiler, diameter	4-ft. 10-ins.	5-ft. 7 ins.	5-ft. 7-ins.	6-ft. 2¼-ins.	6-ft. 8-ins.
Working pressure	228 lbs.	205 lbs.	205 lbs.	200 lbs.	200 lbs.
Tubes, No.	139	261	315	322	446
Tubes, diameter	2¼-ins.*	2¼ ins.	2-ins.	2¼-ins.	2-ins.
Tubes, length	14-ft. 5¼-ins.	17-ft. 8-ins.	16-ft. 4-in.	19-ft. 6-ins.	15-ft. 6-ins.
Heat. Surface; tubes, sq. ft	2,436	2,698	2,680	3,679	3,599
" " total, sq. ft	2,616	2,864	2,882	3,882	3,779
Grate area, sq. ft	34	55½	55	55	55½
Tractive force, lbs	19,555	23,300	23,300	27,520	45,700
Coal in tender	11 tons	10 tons	10 tons	10 tons	13 tons
Water in tender	5,500 galls.	5,500 galls.	5,500 galls.	7,000 galls.	7,000 galls.
Builder	(French)†	Baldwin Loco. Wks.	Am. Loco. Co.	Am. Loco Co.	Am. Loco. Co.

* Serve ribbed tubes. † Societe Alsacienne des Constructions Mecaniques.

OIL-BURNING LOCOMOTIVES are reported to have been insisted upon by the U. S. Division of Forestry as a condition for a right-of-way for the Western Pacific Ry. through the Plumas forest reservation (California).

A MUZZLE VELOCITY OF 3,410 FT. PER SECOND was attained in a test of the 6-in. Brown wire gun at the Sandy Hook, New York, proving grounds on Jan. 23, 1903. This record is characterized by the officers conducting the test as, "by all odds the greatest velocity ever obtained from any gun of the caliber and length of the Brown gun." The gun was a projectile weighing 100 lbs., propelled by 72½ lbs. of smokeless powder.

THE VALIDITY OF THE COLORADO IRRIGATION districts law has been affirmed by the Supreme Court of that state. The act was passed in 1901 and under it bonds have been issued, the validity of which, so far as the constitutionality of the law is concerned, is now established.

THE SEWAGE PATENT INFRINGEM... brought against the city of Plainfield, N... American Sewage Disposal Co., of Boston... progressed (or receded, according to the v... step more: The U. S. Circuit Court, ... Jersey, has refused the petition of the com... an extension of time for taking testimony... was begun in 1902, on allegation that th... and contact filters constituted an infringe... old Amasa Glover patents. The last te... taken on May 13, 1903, after which date the ... the Plainfield case was admitted into a ... brought in another court, against the city o... R. I. The latter case, as was noted in ... Sept. 8, 1904, and Aug. 31, 1905, has ... against the complainant company in both ... Circuit Court and the U. S. Circuit Court ... Still later, if we are correctly informed, the ... preme Court refused a petition for an appeal ... denying the application for more time in wh... testimony in the Plainfield case the court de... the company virtually abandoned its Plainfield ... ing chances of a favorable decision in another ... tion. As it appeared that the additional testimony now proposed in the Plainfield case is cumulative rather than new, the court declares the complainant company "guilty of laches" and denies the motion for an extension of time to take testimony. Presumably this ends the Plainfield case, since if it now went to argument and to decision the evidence would, so far as it goes, be identical with that in the Pawtucket case, which has already been lost.

FOUR 1,200-HP. INDUCTION MOTORS will be installed in the new reduction plant of the Anaconda Copper Mining Co., Anaconda, Mont., by the Allis-Chalmers Co., of Milwaukee, Wis. Each of the motors will weigh over 40 tons. The motors will be used in the concentration building which is 600 ft. long, through which a main line shaft extends the entire length. The motors will be rope-connected to this shaft and will carry the entire power load.

TWO NEW STATE PRISONS FOR NEW YORK have been recommended by a special commission, consisting of State Superintendent of Prisons C. V. Collins and four others, appointed by Governor Higgins. The proposal is to abandon both Sing Sing and Auburn, building a prison to accommodate 1,400 somewhere south of Poughkeepsie, and one to accommodate 1,000 or so in the western part of the state. The two existing prisons have been valued by insurance inspectors at about $2,000,000, and their sale is recommended. Sing Sing is condemned for the following reasons:

(1) The building is damp—the cells especially so. (2) The cells are too small. (3) The cell house is not ventilated. (4) The cells are insufficiently ventilated. (5) The defective plumbing fixtures and drainage system, together with the offensive night buckets, are the cause of much foulness. (6) The variation of the temperature between the upper and lower tiers of cells is excessive. These conditions cause lassitude, prison fever, tuberculosis and other diseases.

The conditions at Auburn are not so bad, but are said to be beyond remedy, at reasonable cost, by remodelling the prison. At Sing Sing, the low, damp ground renders the site wholly unsuitable for prison purposes.

AN 1,800 HP. GAS ENGINE operating a 1,000-KW. generator will form a part of the power plant of the Crystal City Works of the Pittsburg Plate Glass Co. This engine is of the well known four-cycle, double-acting, "Nurmberg" type, built by the Allis-Chalmers Co., Milwaukee, Wis. It is a horizontal, four cylinder, twin tandem engine with a 42-in. stroke and a speed of 107 revolutions per minute. The unit is designed to operate from producer gas, generated from "Big Muddy" Illinois bituminous coal. All moving parts are arranged for automatic and continuous lubrication under pressure.

The gas engine and alternator will be arranged to run in parallel with other units. The alternator is of the Allis-Chalmers revolving field, engine type, three-phase, 25 cycles and is mounted directly on the crank shaft between the two machines.

THE U. S. RECLAMATION SERVICE FUND now amounts to $27,818,352, according to an official statement from Washington. This fund, as many of our readers know, is being utilized for irrigation work in the West and is accumulated from the proceeds of sales of public lands. The additions to the fund in 1905 and the totals to the close of that year, by states and territories, and in the aggregate, are as follows:

Arizona	$50,386	$216,772
California	498,488	2,470,397
Colorado	318,546	1,909,714
Idaho	383,222	2,028,751
Kansas	30,434	128,273
Montana	349,530	2,098,533
Nebraska	179,108	657,110
Nevada	11,108	59,321
New Mexico	133,244	553,446
North Dakota	807,792	4,213,893
Oklahoma	490,630	3,042,767
Oregon	610,797	4,841,457
South Dakota	217,688	960,469
Utah	77,653	380,014
Washington	541,773	3,187,136
Wyoming	196,046	1,070,299
Total	$4,805,515	$27,818,352

THE YELLOW RIVER BRIDGE, the greatest engineering work in China, was formally opened on Nov. 13 last. From an account just received from Mr. John C. Ferguson, Chief Secretary of the Imperial Chinese Railway Administration, we learn that the bridge is a structure of many short spans, supported on piers of hollow cast-steel screw-piles, which are filled with concrete after being driven. There are 50 piers on the approaches (24 on the south side and 26 on the north) built of 8 piles each; and 53 piers in the center of the bridge built of 10 piles each. The span between the smaller piers is 80 ft. c. to c. and of the larger piers, 114 ft. The diameter of the piles is 14 ins. and of the screws, 4 ft.; the steel is ⅞-in. in thickness. The weight of the piles is 135 lbs. per ft., and of the screws, 400 lbs. In all there are 940 piles, all of which have borne a testing load of 75 long tons per pile. The total length of the bridge between abutments is 9,860 ft. The elevation of the rail above low water is 25 ft. and the depth of the river below low water varied from 0 to 30 ft. before the bridge was built. On account of the rapid rush of the water in times of flood, it has been necessary to protect the piers against scouring by fascine work covered with riprap. This has changed already the maximum depth of the river to less than 23 ft., with an average of 12 to 15 ft. Both banks of the river have been protected against erosion by riprap and on the north side defensive works extend up the river to a distance of about six miles. About 60,000 cu. yds. of riprap have been used for pier protection, and about 25,000 cu. yds. have been used along the south bank, and 225,000 cu. yds. on the north bank. The weight of wrought steel in the bridge trusses is 3,760 tons, and of cast steel in the piers is 7,580 tons. The steel has been supplied mostly by Le Creusot, of France, and Cockerill, Baume Et Morpent, La Metallurgique, of Belgium. The approximate cost of the bridge is Taels, 2,000,000. The whole work has been done under the supervision of Monsieurs Jean Jadot and J. Clavier, engineers. It is expected that within a year through trains will make the distance from Hankow to Peking in 24 hours. The bridge has been about 17 months in construction, the first pile having been driven Dec. 21, 1903, and the last one May 3, 1905. The erection of trusses began Aug. 17, 1904, and was completed June 1, 1905. The first train crossed the bridge June 11, 1905, and it was thrown open to the running of regular trains Dec. 20, 1905. The bridge is approached on the south side almost immediately from the mouth of a tunnel which is 1,050 ft. in length. At the opening ceremonies the Chinese Government was represented by the Director-General of Railways, H. E. Sheng Kung-pao, and representatives of the Belgium, French, English, German and other foreign legations were present.

LABOR IN THE SOUTH is claimed to be so scarce as to seriously check industrial development. In a recent address at Atlanta, a cotton manufacturer stated that from a fourth to a third of all the spindles in Southern cotton mills are now idle for lack of operatives to run them.

THE HIGHEST RECORDED VELOCITY OF UNDERground water is said to be 144 ft. in 24 hours, against a previous record of 100 ft. The new record is for water flowing through gravel near Tucson, Ariz. The observations were made during the last Christmas holidays by Mr. H. C. Wolff, of the Department of Mathematics, of the University of Wisconsin. Mr. Wolff had been commissioned by the Chief Hydrographer of the United States Geological Survey to spend the Christmas holidays giving instructions to the members of the engineering department of the University of Arizona in the methods of measuring the rate of movement of underflow streams. The University of Arizona is carrying on this work for the purpose of developing the water resources for irrigation in the neighborhood of Tucson.

OIL WELL WASTES IN CALIFORNIA have become a subject of litigation. The Kern County Land Co. and other companies near the Kern River oil field have brought suit against the Associated Oil Co., said to be an auxiliary of the Southern Pacific Ry. Co., to prevent possible damage of water supplies and lands from the oil wastes. It is said that thus far no damage has been done, but that it is threatened, only.

THE DESIGN OF IRON WORK RESTING ON MASONRY.*

By L. K. Sherman.†

One of the most frequent details of modern construction is the placing of anchor bolts, bed plates and foundation castings in concrete. The ordinary type of anchorage consists simply of a bolt with a large washer or plate. The nut is supposed to bear against this anchor plate and so transmit the pull on the rod to the concrete. In setting these anchor bolts, unless exceptional care is taken, the workmen in placing the concrete will move the plate away from the nut or the bolt will settle down in the concrete and carry the nut away from the plate. In this event, however slight the space between plate and nut, the utility of the anchor plate is entirely destroyed. The remedy for this trouble is very simple. Two nuts should be provided with every anchor plate, one above and one below the plate. By this means the plate is secured rigidly to the rod and is free from all possibility of displacement.

There seems to be no rule among designers as to the proper length of anchor rods. The evident mental process, in fixing the length of an anchor, is that iron is cheap and a few extra feet will make assurance doubly sure. The fact is overlooked that every foot of length increases the difficulty in keeping this rod in position while concrete is being placed. It requires great care to hold a dozen rods in place, during construction, so that they will finally fit the holes in the bed plates or pedestal castings, even when collar spaces are left about the rods. One often sees anchor rods, subject to shear only, made 6 ft. long when 6 ins. would be nearer the proper length. The writer suggests the following rules for correct proportions of anchor rods:

(1) Short bolts, without anchor plates, in tension: The area of bedded surface of bolt, multiplied by the adhesion per sq. in., should equal the tensile strength of the bolt at the root of thread. The adhesion may be taken at 200 or 250 lbs. per sq. in. of surface for Portland cement mortar.

(2) Rods, with anchor plates, in tension: The shearing strength of the concrete (taken at 60 lbs. per sq. in. over a surface equal to the circumference of the anchor plate multiplied by the bedded depth) should equal the tensile strength of the bolt.

(3) Bolts in shear only: Length of bolt need not exceed from six to twelve times the diameter of the bolt.

Cast pedestals, with rib walls, forming pockets, which are to be filled with concrete or mortar, should be provided with holes to act as air vents where the casting is lowered into a bed of mortar, or better yet, hand holes should be provided large enough to permit grouting up any vacant spaces.

Heavy and cumbersome pieces of iron work which have to be set in concrete to very accurate line and level, should be provided with some means of adjustment. For example: In the bear trap dam on the Chicago drainage canal, the frames for heavy track bars were supported on screws which were a part of the design. After exact adjustment, the frames, screws and all were entirely bedded in concrete. These screws were used but once, serving their entire purpose, but they were well worth their cost in comparison with the usual construction appliances such as wedges, bars, shims or jacks, which are clumsy for precise adjustment in cramped places. It may be stated as a principle of good design that when heavy iron work is to be set in masonry to exact position, that the parts should be so arranged as to allow the base piece, which is in contact with the masonry, to be set in close approximate position and the connection with the iron base to the upper piece be made adjustable for precise alinement.

The writer once met with a plan which called for the placing of a heavy cast pedestal provided with anchor rods placed at 45° with the vertical and extending in opposite directions through cored holes in the casting. This is a very substantial construction, and on paper appears very satisfactory. The objection to this design was discovered in attempting to set the casting over the rods, which were in position in the concrete.

*Abstract from a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors, Rockford, Ill., Jan. 17, 19, 1906.

†Resident Engineer of the Power Plant for the Chicago Drainage Canal, Joliet, Ill.

PERSONALS.

Mr. Edward S. Murphy is the new Superintendent of Buildings of Manhattan Borough, New York City.

Mr. Earle W. Green, formerly with the Wabash, Pittsburg Terminal Ry., is now office engineer with the Pittsburg & Butler Electric Railway.

Mr. J. A. Peterson has resigned his position with the American Steel & Wire Co., to accept a place with the wire inspection bureau of New York City.

Mr. E. H. Bowser has been appointed Chief Timber Inspector in charge of inspection and treatment of ties and timber of the Illinois Central R. R., with office at Memphis, Tenn.

Mr. Henry G. Morehouse has been appointed special assistant engineer of city survey in the bureau of engineering and survey, of Denver, Colo., for a probationary period of six months.

Mr. William H. Larned has been appointed Consulting Engineer to the Board of Public Works, San Francisco, Cal., for the construction of the Geary St. line, in place of Mr. J. C. H. Stut.

Mr. J. A. Johnson, who has been in the employ of the Niagara Construction Co., has accepted a position with the operating engineering force of the Ontario Power Co., at Niagara Falls.

Mr. H. S. Downe is manager of the English branch of the American Radiator Co., at Hull, Eng. This company is about to erect extensive shops in that city for the manufacture of its regular line.

Mr. L. E. Granke, an Engineer of the U. S. Reclamation Service, has recently accepted a position as Superintendent of Construction with the FitzSimons & Connell Co., Contractors, Chicago, Ill.

Mr. B. Kinsley, Superintendent for the Henry Dumary Contracting Co., Brooklyn, N. Y., in charge of an electrical conduit construction for the Brooklyn Rapid Transit Co., has severed his connections with this company.

Mr. Horace E. Andrews, formerly President of the Cleveland Electric Ry., of Cleveland, O., will take control this week of the trolley systems of the New York Central & Hudson River R. R., in place of Mr. W. K. Vanderbilt.

Mr. W. L. Sisson, formerly Chief Engineer of the projected extensions to the National Bolivian R. R., has been appointed principal Assistant Engineer for the construction of the new docks and piers of Baltimore, Md., by the Harbor Board of that city.

Mr. C. C. Mallard, formerly Assistant Superintendent of the Louisiana Lines of the Southern Pacific Co., has been appointed Superintendent of the Gila Valley, Globe & Northern Ry. Co., with headquarters at Globe, Ariz., succeeding Mr. W. R. Martin, resigned.

Mr. W. K. Palmer, Consulting Engineer, 718 Dwight Building, Kansas City, Mo., has established a branch office in Memphis, Tenn., at 52 Porter Building, in charge of Mr. L. C. Wilson, formerly chief engineer of the office in Kansas City. This office is directing the construction of a plant for the Standard Box Company, at Memphis.

Mr. J. W. Woermann, M. Am. Soc. C. E., formerly U. S. Assistant Engineer, has opened an office for the practice of civil and hydraulic engineering at 603 Observatory Building, Peoria, Ill. While in the government service he was engaged for some years on the surveys of the Illinois and Desplaines Rivers in connection with the proposed deep waterway.

Mr. W. A. Gardner, General Manager of the Chicago & Northwestern Ry., has been appointed vice-President, in charge of operation, and Mr. R. H. Aishton, Assistant General Manager, has been promoted to be General Manager. Mr. W. E. Cantillon, General Superintendent, becomes Assistant General Manager, and is succeeded by Mr. W. E. Morse, Division Superintendent.

Mr. Union N. Bethell has announced his retirement as General Manager of the New York Telephone Co., 14 Dey St., New York City, but he will continue as vice-President of this company, as well as President of the New York & New Jersey Telephone Co. and eight other eastern companies. Mr. H. F. Thurber will be General Manager and Mr. J. J. Carty will be Chief Engineer, hereafter, of both the New York Telephone Co. and of the New York & New Jersey Telephone Co.

Mr. L. L. Bentley, of Bethlehem, Pa., has been appointed vice-President and General Manager of the Oswego Boiler & Engine Co. and will be the active head at Oswego, N. Y. Mr. Bentley is a Pittsburg man, about 35 years of age, a graduate of Cornell University in Mechanical Engineering and has had a wide experience in the design and construction of boilers and plate work. He comes to Oswego from the Lehigh Valley R. R., where he has been Mechanical Engineer for some years.

Mr. Kingsley L. Martin, M. Am. Soc. C. E., Assistant Engineer in charge of the Williamsburg Bridge, New York City, has been made Engineer in charge of both this bridge and Brooklyn Bridge. Mr. Martin is a son of the

late C. C. Martin, who was the Chief Engineer of the Brooklyn Bridge from its completion until his death a few years ago. Mr. Archibald McLean will continue as Assistant Engineer in charge of Brooklyn Bridge, and Mr. Olaf M. Kelley has been designated as Assistant Engineer in charge of the Williamsburg Bridge, both under the direction of Mr. Martin.

Mr. Henry A. Allen, M. Am. Soc. M. E., who was for eleven years with the Fraser & Chalmers Co., and its successor, the Allis-Chalmers Co., has opened an office at 1435 First National Bank Building, Chicago, for practice as a consulting, mechanical, hydraulic and electrical engineer. He was for some years mechanical and electrical engineer of the Allis-Chalmers Co., in charge of the Riedler pumping engines and air compressors, in which position he designed and installed a number of notable pumping plants. During the past year he was in charge of the company's steam turbine department.

Mr. Colin M. Ingersoll, Jr., M. Am. Soc. C. E., has been appointed Chief Engineer of the Department of Bridges, New York City, by Commissioner of Bridges James W. Stevenson, to succeed Mr. O. F. Nichols, M. Am. Soc. C. E., who has been made Consulting Engineer of this department at a salary of $10,000 per year. Mr. Ingersoll is now connected with the New York, New Haven & Hartford R. R., as Comissiomner of Real Estate, Right of Way and Taxes. Previous to October last he was for five years Chief Engineer of this road, and during that time planned and supervised its six-tracking from New Rochelle to the Harlem River, as well as many other important changes. Mr. Ingersoll graduated from the Sheffield Scientific School at Yale in 1880, and has been in the employ of New York, New Haven & Hartford R. R. since 1881, with the exception of the year 1892, when he served as City Engineer of New Haven, Conn.

Mr. Alex. C. Shand, Assistant Chief Engineer of the Pennsylvania R. R., has been advanced to the position of Chief Engineer, succeeding Mr. Wm. H. Brown. The retirement of Mr. Brown on pension removes from active service one of the oldest and best known railway engineers in the United States, and an official who has seen the railway with which he was so long connected grow from a small system to an aggregation of lines which has perhaps no equal in the world. Mr. Brown was born in Lancaster County, Pennsylvania, Feb. 20, 1836. He received his education at the Philadelphia High School and took up the profession of engineering. In October, 1861, at the age of 25, he was appointed by Col. Thomas A. Scott engineer of military railroads in Northern Virginia, handling this difficult position with signal ability. In 1862 he became engaged as assistant engineer on the Pittsburg, Ft. Wayne & Chicago R. R.; in 1864 on the Pittsburg Division of the Pennsylvania R. R.; in March, 1865, on the Oil Creek road, and in July, 1865, principal assistant engineer of the Philadelphia & Erie R. R. In 1869 Mr. Brown took charge of the shops of the Pennsylvania R. R., and subsequently held several engineering positions with that company until Aug. 1, 1874, when he was appointed Chief Engineer. Practically speaking, Mr. Brown's life work may be said to have been devoted to the engineering problems of the Pennsylvania R. R., a task in which he displayed high ability and remarkable energy.

Obituary.

L. C. Kenyon, a civil engineer, residing at 213 Buena Vista Ave., Yonkers, N. Y., died Jan. 26.

Captain Edward Delfosse, the builder of the Panama Canal breakwater at Colon and a well-known shipmaster, died Jan. 20 at New York City.

Harvey B. Hurd, a well-known lawyer of Chicago, Ill., and one of the original promoters of the Chicago Drainage Canal, died recently at his home in Evanston, Ill.

James E. Graff, County Surveyor, Chicago, died at St. Joseph, Mo., Jan. 20. He was born in Westmoreland County, Pa., in 1860, and went to Chicago in 1888. He had been county surveyor for four years.

Jesse Boynton, formerly a well-known bridge builder and President of the Columbian Iron Works, of Baltimore, Md., died in Newport, R. I., Jan. 18. Mr. Boynton was at one time prominently identified with bridge building in the South.

Stephen Russell Kirby, one of the founders of the Detroit Drydock Co., which built the first iron and steel boats that sailed on the Great Lakes, died Jan. 27 in his apartments at the Hotel Martinique, New York City, at the age of 82 years.

Herman J. G. Sprengel, inventor of the well-known Sprengel pump for the production of vacua, died Jan. 14, at London, Eng. Dr. Sprengel was trained at Göttingen and Heidelberg Universities and has made several notable contributions to chemistry and physics.

Anson W. Buttles, a pioneer surveyor of Milwaukee Co., Wis., died Jan. 21 at the age of 84 years. Mr. Buttles was a native of Milton, Pa., and was employed in construction work on the Baltimore & Ohio R. R., the first steam road of consequence built in the United States. After going to Wisconsin in 1843, he was employed on surveys for the old Milwaukee & Mississippi R. R., now the Prairie du Chien division of the Milwaukee system. The first rails in Wisconsin were spiked down to a grade that was staked out by Mr. Buttles.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 21. Annual meeting at South Bethlehem, Pa. Secy., R. W. Raymond, 99 John St., New York City.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 20. Annual meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.—A reception will be tendered to Professor Wilhelm Ostwald by the New York Section of this society on Feb. 2, at the Chemists' Club, 108 W. 55th St., New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—Announcement has been made that sufficient funds will be available from the net income of the trust fund, created in 1904, to establish the "Edison Medal," to provide for the award of this medal for the year 1906. Particulars as to the conditions under which the medal is awarded may be obtained from the secretary.

ILLINOIS CLAY WORKERS' ASSOCIATION.—The annual meting was held at Champaign, Ill., Jan. 23. The following were among the papers read: "The Clay Working School," Mr. F. W. Butterworth, Danville; "Drain Tile and Tile Drainage," Mr. Walter D. Pratt, Earlville; "The Relation of the Illinois Geological Survey to the Clay Workers," Mr. H. F. Bain, Director of the Survey, Urbana; "Clay Products in Recent Fires," Mr. D. D. Gates, Chicago; and "Economy in Steam Power," Warren Ittner, Belleville. There were also discussions on "Tile Drainage and its Benefits," and "Which is the Better, Shallow or Deep Drainage."

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK.—The third annual meeting was held on the evening of Jan. 24, at the Chemists' Club, 108 W. 55th St., New York City. President S. C. Thompson delivered the annual address, which included a general review of the municipal work of all the departments now in progress or proposed. New officers were elected as follows: President, Mr. Geo. W. Tillson; First Vice-President, Mr. Geo. S. Rice; Second Vice-President, Mr. Robert Ridgeway; Secretary, Mr. Wisner Martin; Treasurer, Mr. A. S. Tuttle; directors, Messrs. Martin Gay, H. K. Endeman, W. R. Hillyer, E. H. Hartmann, Geo. R. Olney, E. F. Austen.

ASSOCIATED EXPANDED METAL COMPANIES.—This association held its annual meeting at Washington, D. C., Jan. 25. The speech of the day was made by Captain J. S. Sewall, of the United States Army, in charge of the construction work at the Army War College, Washington, who spoke on "The Reinforcement of Concrete." He gave a historical sketch of the development of reinforced concrete from its invention down to the present day, and dwelt particularly on the advantages of the use of web members in strengthening concrete-steel structures. He discussed at length the serious obstacle that reinforced concrete encounters in the building laws of many cities, which are inconsistent and absurd in many important particulars. He gave many examples, taken especially from the laws of New York City. These laws lead either to clumsy structure on the one hand or a false sense of security on the other. Following the address the members indulged in an open discussion of the subject and a number of opinions from leading engineers of the country were listened to with interest. Mr. C. W. Summerville, of the building inspector's office, district government, told some interesting experiments which had come to his notice in the use of reinforced concrete. An interesting feature of the meeting was the exhibition and explanation of several models of the new steel "Monolith" bar, recently invented and about to be put on the market by J. F. Golding, of Washington, the inventor of expanded metal.

OHIO ENGINEERING SOCIETY.—The annual meeting was held at Columbus, O., Jan. 22, 23, 24, about 80 members being present and 37 new members being elected. The special committee on legislation presented a bill providing for the establishment of a state board of registration and examination for civil engineers and surveyors, which was adopted after long discussion, with slight change. A special committee, consisting of Mr. C. A. Judson, Prof. C. E. Sherman (Ohio State University), Mr. John Laylin, Mr. J. M. Harper, and the incoming President and Secretary, was appointed to present the bill to the General Assembly and urge its passage.

Bills providing for further investigation of sewage disposal and water purification plants by the State Board of Health, and for legalizing the use of [illegible] street and road sprinkling were endorsed, as was a salary law for county surveyors. A special committee was appointed to act with committees of other engineering societies on the subject of pollution of streams.

Two special sections of the Society were organized as follows: County surveyors' section, J. L. Gilpatrick, President; Municipal section, R. E. Kline, President. The following papers were on the program: "The Movement for Better Roads," Mr. H. C. White; "Highways in Ohio," Mr. S. Huston; "The Relation of Geology to Engineering," Mr. T. C. Connar; "The Water Softening Plant at Oberlin," Mr. W. B. Gerrish; "The Scioto River Dam," Mr. A. Stellhorn; "Natural Cement in Engineering Construction," Mr. J. A. Fairleigh; "The Organization of Bridge Companies," Prof. W. H. Boynton; "Water Purification at Lorain," Mr. Paul Hansen; "Watertight Joints," Mr. E. A. Kemmler; "The Work of the Reclamation Service," Mr. M. O. Leighton; "Submit County Drainage and Ditches," Mr. J. A. Gebhart; "The Adjustment of Intersecting Grades on Highway Streets," Mr. A. J. Norton; "The Construction of Streets and Street Railway Tracks," Mr. F. E. Myers; "The Engineer and the Highways," Mr. C. A. Judson; "Dredging the Scioto River," Mr. J. W. Gilmore; "Street and Road Sprinkling," Mr. J. M. Harper; "Concrete-Steel Bridges at Dayton," Mr. R. E. Kline and Mr. G. R. Stattelman; "Difficult Problems in Building Construction at Youngstown," Mr. J. B. Strawn; "The Commercial Uses of Structural Steel," Mr. J. C. Spencer.

The election of officers resulted as follows: President, G. A. McKay; Vice-President, John Laylin; Secretary and Treasurer, E. G. Bradbury, Columbus, O.

NORTHWEST CEMENT PRODUCTS ASSOCIATION.—The second annual meeting was held at Minneapolis, Minn., Jan. 17, 18 and 19. The convention was opened by an address of welcome by Mayor D. P. Jones, of Minneapolis, after which the reading and discussion of technical papers was begun. The first paper by Hon. Lee Stover, of Watertown, S. Dak., was a general talk on the subject "How Conventions Can Help Us." It was followed by a long paper, entitled "Some of Our Troubles and How They Come About," by Mr. Arthur N. Pierson, of New York City. Mr. Pierson reviewed the various causes leading to trouble in the manufacture of concrete blocks and laid particular stress on the necessity and advantage of carefully grading the sand and aggregate from fine to coarse. The President's address, by O. U. Miracle, reviewed the work of the officers of the association during the year, and called particular attention to the proposed standard specifications for concrete blocks prepared by a committee of the National Association of Machinery Manufacturers. (This specification was read at a later session and will be published in an early issue of Engineering News—Ed.) Mr. Mirical closed his address with the following interesting statement:

> As I have said before, the great growth of this industry has made it a very inviting field for the investor. Many have gone into the business with little idea of its requirements, but they have been thorough students of the proposition, and only by a continuation of these studious efforts can we hope to maintain the industry on the high plane to which it belongs. Many have also made serious mistakes; both mistakes of commission and omission. These mistakes have brought on many criticisms—some just and some unjust. These objections made are being rapidly and readily overcome. One of the most serious objections, and one at the same time most readily overcome, is that of appearance of the concrete block in the building, and it comes most forcibly from the architect, who is naturally slow to leave the well-trodden paths of established practice for exploring what is to him an unknown field. His worst criticism is the everlasting, abominable rock face block which you have all made, and which in construction resembles the cheapest sheet-iron effect. Nothing is easier than for you to get away from this uniform effect. No material is so easily susceptible and responsive to the artistic touch as concrete, and I trust you will look more to that end of the business in the future. Quality, of course, comes first and must be considered above all. The architect has already discovered that the material is already being used, and is ready to consider it for his wants, and it is up to you to produce an article that will fill his wants.

Mr. D. M. Harper, of Detroit, Mich., gave an interesting and practical talk; his theme was: "A Fair Price for Honest Work." We are not engaged in the concrete business for our health, and if we are to continue in it, we should stand for reasonable prices that will warrant doing first-class work at a reasonable profit. Mr. L. L. Bingham's paper on 'Cement Tile for Farm Drainage' took the position that the farmer could generally better afford to buy the tile than to undertake the manufacture himself, as in buying from those who make the business of manufacturing, he saves the expense of equipments. Mr. McClenahan's paper on "Manufactured Stone" was interesting and valuable.

On the evening of the 18th Mr. C. A. P. Turner gave an illustrated lecture on "Reinforced Concrete"; an abstract is published in another column of this issue. Other papers read were: "Concrete, Its Uses and Abuses," by Mr. Henry Longcope, Philadelphia, Pa.; "The Rational Interpretation of Cement Tests," by Mr. John E Moore, Chicago, Ill.; "The Concrete Block Industry of the Future as Indicated by Past Experiences," by Mr. A. P. Melton of Minneapolis, Minn., and "Concrete," by Mr. R. G. Coutts, Grinnell, Ia.